Vol. XLII JULY, 1923 No. 7

JOURNAL OF THE American Institute of Electrical Engineers

PUBLISHED BY THE INSTITUTE
33 WEST 39TH ST • NEW YORK CITY

American Institute of Electrical Engineers

COMING MEETINGS

Pacific Coast Convention, Del Monte, Calif., October 2-5

MEETINGS OF OTHER SOCIETIES

American Electrochemical Society, Dayton, Ohio, September 27-29

American Institute of Mining and Metallurgical Engineers, Ontario and Quebec, August 20-31

Association of Iron and Steel Electrical Engineers, Buffalo, N. Y., September 24-28

Illuminating Engineering Society, Lake George, N. Y., September 24-28

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OF THE

American Institute of Electrical Engineers

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JOURNAL

OF THE

American Institute of Electrical Engineers

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street, New York

Subscription. $10.00 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippines; $10.50 to Canada and $11.00 to all other Countries. Single copies $1.00.

Entered as matter of the second class at the Post Office, New York, N. Y., May 10, 1905, under the Act of Congress, March 3, 1879. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.
Printed in U. S. A.

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The Electrical Plant of Transocean Radio Telegraphy

BY E. F. W. ALEXANDERSON, A. E. REOCH and C. H. TAYLOR
Fellow, A. I. E. E. Associate, A. I. E. E.
All of the Radio Corporation of America

Review of the Subject.*—A description of the expansion of the Transocean Communication System of the Radio Corporation of America from a few isolated plants to a unified group of electrical plants all controlled for communication purposes from a central traffic in New York City, with a summary of the technical conditions covering the design of the Radio Central Station and of the technical conditions to be met in operating efficiently a modern radio communication system.*

At the beginning of 1920 the United States Government removed the war restriction on commercial radio service, and the Navy Department restored to the Radio Corporation of America those stations which were built and equipped in 1914 by the Marconi Wireless Telegraph Company of America for transocean service.

In addition to the agreements previously entered into with countries in Europe for transocean radio service, the Corporation faced the situation arising out of the Great War, in which practically every European country demanded direct radio commiunca-tion with the United States.

The need for the provision of modern facilities for carrying on radio communication with those countries with which agreements had already been made, was imperative, and hardly less imperative was the need for the expansion of our facilities to meet the new situation.

The radio equipment in all of the installations restored to the Corporation was of obsolete type and based on the use of damped waves, except in the case of the New Brunswick station. At that station the Navy Department had instructed the General Electric Company to install high-frequency alternator equipment and to modify the antenna circuit to meet the requirements of their system. Accordingly, an alternator equipment was installed which was able to supply to the antenna circuit 200 kilowatts at the high frequency to which the antenna circuit is tuned. The antenna at this station had been erected as an inverted L, approximately a mile long and 550 feet wide. This was changed to the multiple-tuned type by adding five tuned down leads, equally spaced along the length of the antenna, and connecting them through a balanced distribution system to the ground and counterpoise wires. This installation has been described by technical papers read in 1920 and 1921.

Operation of the system of the Radio Corporation started with two transmitting stations — at New Brunswick, New Jersey, and at Marion, Massachusetts. Each of these transmitting stations had its corresponding receiving station at Belmar, New Jersey, and at Chatham, Massachusetts, respectively. New Brunswick was used for communication with England, and Marion for communication with Norway. The telegraphic operation of the English circuit was centered in Belmar, and the operation of the Norwegian circuit was centered in Chatham. Messages to England or Norway were telegraphed to Belmar and Chatham respectively, where they were copied and transmitted over the radio circuit via New Brunswick and Marion. Similarly, messages from England and Norway were received in Belmar or Chatham, were copied by hand, and re-telegraphed to New York. This process involved several relays of telegraph operators with the consequent high expense and possible delays and errors.

With the present system of operation, the Radio Corporation has six transmitters on the Atlantic coast, two in Tuckerton, one in New Brunswick, one in Marion, and two in the Radio Central station on Long Island. All these transmitters are controlled directly from the traffic office in New York City.

Only one receiving station is needed for all incoming messages. This receiving station is located at Riverhead, Long Island. It has a single antenna of a new and special type, which will be described later. This antenna intercepts the waves from all European transmitting stations. The receiving apparatus, also of a new type, separates this conglomeration of ether waves which come in over the receiving antenna, into separate messages which are automatically relayed over telephone wires so that all messages are received and copied in the same traffic office in New York.

The transmitting station on Long Island — known as "Radio Central" — and the receiving station at Riverhead, Long Island, represent the modern system of the Radio Corporation. The stations at New Brunswick, Marion, and Tuckerton, are adaptations of the modern transmitting apparatus developed by the General Electric Company and antennas built before the war. The characteristic features of the transmitting system are: The high-frequency alternator, the multiple-tuned antenna, the speed or wave-length regulator, and the magnetic amplifier.

In the Riverhead receiving station the method of centralization has been carried to its logical conclusion by concentration of all radio apparatus in the one station, and concentration of all reception in New York. The advantage of such concentration is obvious. New receiving circuits for communication with any new station in Europe can be added at a negligible cost by installing a new set of receiving apparatus on some of the shelves provided for that purpose in the Riverhead receiving station.

The Radio Central transmitting station has been

Presented at the Annual Convention of the A. I. E. E., Swampscott, Mass., June 25-29, 1923.

planned in such a way that the cost of additional transmitting units will be a minimum. The choice of the site of the Radio Central transmitting station was carefully considered, looking forward to a growth of international radio communication which would require as much as twelve transmitters in this new station. Two of these twelve transmitters are already completed.

The principal considerations in selecting the site for the Radio Central station were:

1. The site must be within a reasonable distance from New York — the center of traffic.

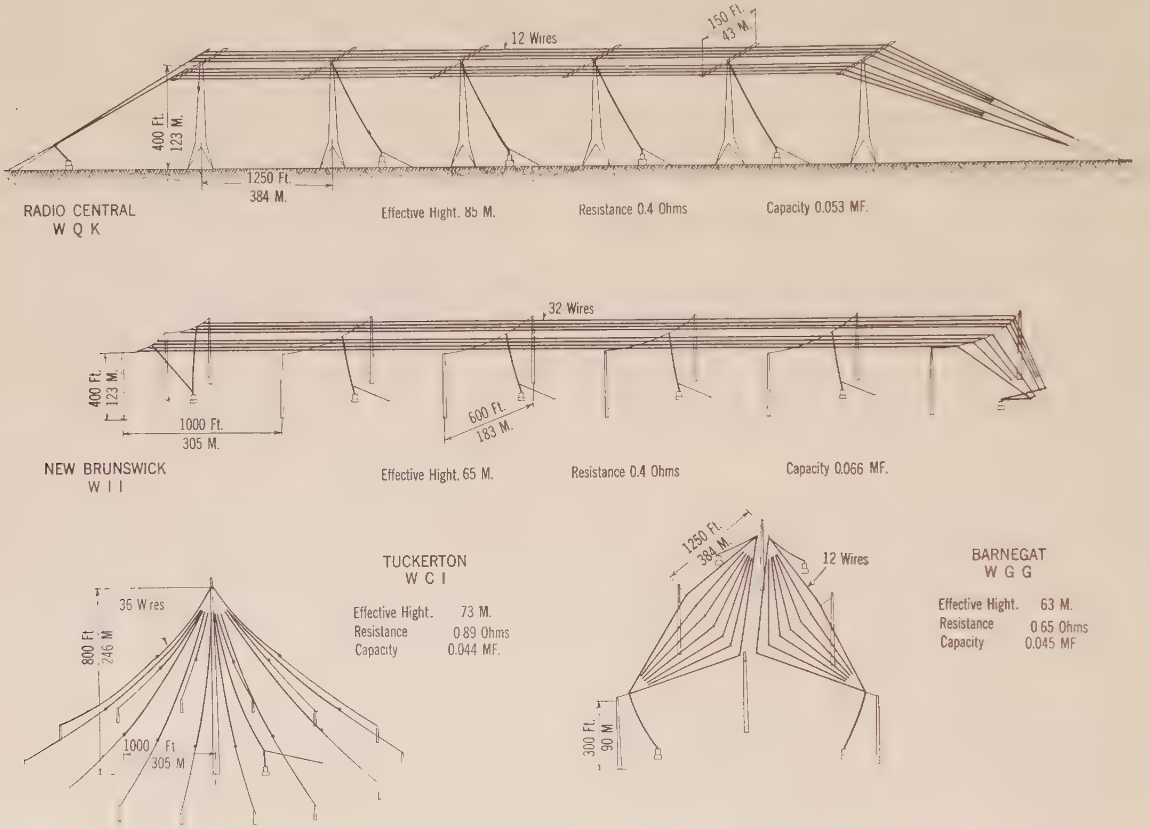


Fig. 1

2. A large tract of land of a desirable nature must be available, at a moderate cost.

3. A good power supply must be within easy reach.

4. There must be direct and reliable wire line communication with New York City.

The site selected on Long Island fulfilled these requirements in an ideal way, but another desideratum which, in the past, had been the deciding factor in selecting sites for transmitting stations, was not fulfilled in the Long Island location — a natural low ground resistance. The Long Island ground consists of quartz sand of extraordinarily high resistance. The decision, therefore, regarding the selection of this site was a grave responsibility for the engineers of the Radio Corporation. It meant a radical departure from the generally accepted theories. It implied that practical operation rather than technical considerations was to be the controlling factor. The engineers thus undertook to remedy by new developments in the technique what nature had failed to provide — a good ground. Much progress had already been made to reduce ground resistance by multiple tuning and ground equalizers, but this experience had been gained in stations like New Brunswick, Marion, and Tuckerton, where the natural ground resistance was low. However, we had sufficient faith in the further possibilities of development of improved grounding methods to take the responsibility for starting the construction of the new station while investigation was going on to find a solution for the grounding problem. The development work of the new ground system required as much time as the completion of the rest of the station, but by the time the station was ready to go into service the ground system was also ready and proved to be successful beyond the most sanguine expectations.

The Radio Central transmitting station of the Radio Corporation of America is the first of our stations that has been planned and designed from the beginning to meet modern requirements, the other stations having been made to conform to modern practise by modification of equipment installed in earlier times. The Radio Central type of station is being duplicated in Poland and Sweden. This station has been frequently described and while its 400 ft. steel towers with 150 ft. cross arms are quite well known, little has been published regarding the technical performance of the plant.

Radiation

The transmission value of the transmitting station is expressed by the product of the effective height — usually given in meters — and the charging current of the antenna circuit — given in amperes. In deciding upon the value of meter amperes that would be required at our Long Island station, we took advantage of the experience gained from work done with the signals transmitted from the Nauen station in Germany and the Carnarvon station in England. As a result of the preliminary work in this connection, a figure of 50,000 meter amperes was decided upon and the antenna circuit was designed to give this value with full power on one transmitting unit.

As this figure of 50,000 meter amperes is made up of two factors, effective height of and current in the antenna circuit, the values assigned to each of these factors must be so chosen that the cost of the antenna, cost of power equipment, and cost of operation and maintenance, will result in the most economical investment. In order to determine the most economical height of antenna, it was necessary to check carefully, the varying effects of capacity, effective height, wave length, voltage and current. The result of these investigations showed that if the first cost of the transmitting station be plotted against the height of the towers for a given value of meter amperes at a given wave length, a curve is obtained showing a distinct minimum. This minimum is not sharp but shows that there is a minimum cost of station for the given meter ampere value over a small range in the height of the towers.

Fig. 2

Design Data: Radio central type antenna; wave length 16,000 M.: Voltage maximum 120,000 M.: meter ampere value: Curve A-50.000, Curve B-100.000.

Fig. 1 gives for comparison the principal dimensions, effective height, and resistance of the four types of antenna used in the Atlantic shore stations of the Radio Corporation. The effective heights are determined by measurements of radiation.

Fig. 2 shows the calculated cost for antenna structures at different heights for two typical stations of 50,000 and 100,000 meter amperes radiation.

The antenna voltage limitations which had been experienced at our older stations necessitated an investigation of the insulators that should be used in connection with these antennas. This work has been described recently in a paper read by Mr. W. W. Brown on March 7th, last, before the Institute of Radio Engineers, and this shows that by careful design and arrangement of parts, we have been able to raise the working voltage of our antennas from around 60,000 to 150,000. In a recent test of the insulators actually installed and operating at our Radio Central station at a voltage of approximately 120,000, it was found that the voltage distribution over the double insulator unit, by means of which the wires are suspended from the bridge arm of the towers, is roughly 45 per cent and 55 per cent, the insulator nearer the tower having the smaller proportion of the voltage.

Power

The power to operate the station is generated in the Long Island Lighting Company's plant at Northport, L. I., and carried by a three-phase network at 22,000 volts, a distance of 30 miles to the radio station. At the radio station, the power is transformed to 2300, two phase, to drive the induction type motors connected through step-up gears to the high-frequency alternators.

Antenna

The suspension of the antenna wires followed current transmission line practise. The wires run the full length of the antenna; standard transmission line clamps are fastened to the wire at each tower suspension point. These are shackled to the insulators suspended from the tower bridge arm. As the working voltage at which this antenna would operate, was higher than that used at our other transocean stations, the design of this circuit was carefully considered with respect to corona losses. The operation of this antenna at 135,000 volts showed that the corona limit was not reached on any portion of the circuit, although there is not a very great reserve where the inner wires unshielded by the suspension insulators, pass across the face of the steel tower.

The antenna consists of 12 parallel wires 5/16 in. diameter 7500 feet long and spaced on an average about 14 feet apart forming an approximately horizontal plane about 150 feet wide. The wires are stretched from dead end structures close to the building to the first tower cross arm then from cross arm to cross arm in a straight line to the sixth tower, then again to a dead end structure at the ground level at the far end.

The self supporting type of tower was selected for use with this antenna. It is equipped with a bridge arm, its length 150 ft. over-all—fixed to the top of the tower. The insulators carrying the antenna wires are suspended from the lower face of this bridge.

Many reasons entered into the decision to use this type of tower, three of which may be mentioned here. One consideration was, the average height of the antenna wires. With a group of similar antenna wires, equally loaded, suspended on a springstay between two towers, the height above ground of the point of suspension of a wire decreases as the distance between this point and the nearest tower is increased. With a similar group of wires suspended from the bridge arm of a tower, there is no similar variation.

Another engineering consideration was the variation in antenna constants caused by high winds. The suspension of the group of antenna wires from a spring-stay slung between the tops of two masts or towers, has been used at our New Brunswick, Marion, and similar stations. It has been found that whenever there is a high wind blowing across the antenna wires, the spring stay assumes a new position varying with the strength and direction of the wind. With gusty winds of high velocity, this change of position is continuously occurring. There is, in addition, the variation in the position of the antenna wires due to the cross wind on the wire span between the spring stays. The result of these changes in position of the wires is that the constants of the antenna circuit change, and detune the antenna from the alternator which is operated at an accurately regulated wave length. The resulting fluctuations in radiation have been so great at times as to seriously impair the commercial effectiveness of this station. Now, with a fixed point of suspension, such as the tower bridge arm, the only variations in position of the wires, are those due to the wind on the wire span between the towers. Those due to the variation in the position of the spring stay are not present.

The antenna circuits at all of our stations are equipped with variometers to correct for these changes and our experience is that the variations are less severe with Radio Central type of antenna than with that of New Brunswick.

As Long Island is well within that zone of the United States in which sleet and glare formation must be expected on all structures exposed to the weather during the winter months, provision has been made to melt such ice as may form around the antenna wires. The heating current for sleet melting, is supplied from the power house, at 60-cycles, through special transformers and reactances. The antenna wires are connected together at the far end of the circuit. By opening switches at the power house end of this circuit, the wires can be disconnected from the radio frequency feeder circuit and the 60 cycle power circuit can be connected. If the several downleads were connected directly to the antenna wires throughout their length the path of the heating current would be short-circuited. Two satisfactory methods have been used to avoid such short circuit. One method consists in dividing the wires into four groups and connecting only the wires belonging to one group at each of the four intermediate points. At both ends, all wires are connected. The other method consists of making the connection of each wire through a specially designed condenser.

The inductors used at each downlead of the multiple tuned antennas are installed without any protection from the weather. This type of installation has proved satisfactory except at some locations close to the sea where the spray from the sea water deposits salt on the insulators.

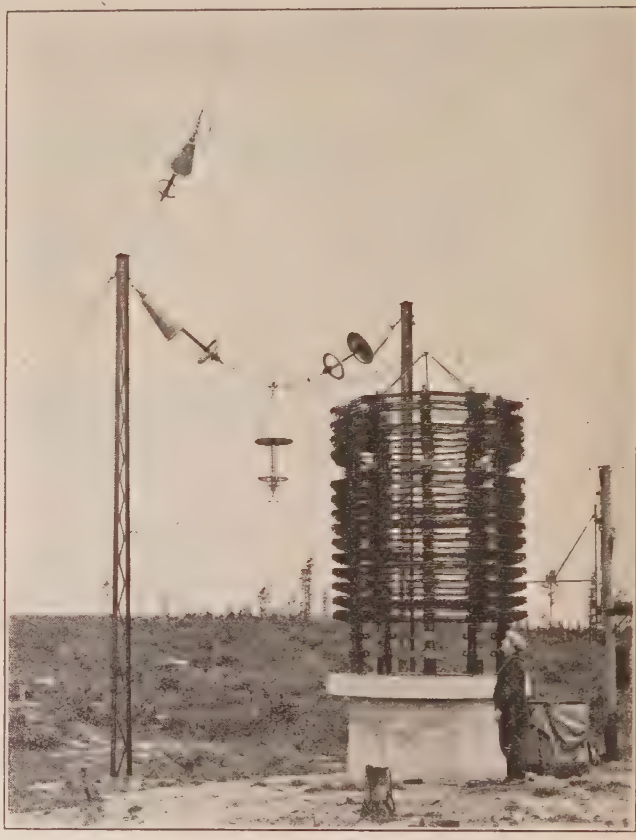


Fig. 3

The standard outdoor coil is shown in Fig. 3. Fig. 4 shows coils housed in frame structures lined with copper.

At stations where more than one antenna circuit is installed, attention must be given to the disposition of the several antennas and of their individual feed circuits in order to minimize their mutual interaction. In enlarging or remodelling an existing station, it is not always expedient to attempt to bring all antenna circuits to the close proximity of the power house. This is particularly true of a station where the original antenna circuit is of umbrella design and where a second antenna circuit is to be installed, which can be operated simultaneously with the first and on a long wave length differing from that of the first by only a few per cent. Such a situation confronted us at our Tuckerton station. The space immediately surrounding the power house was occupied by the umbrella antenna, which was in continuous commercial use. The new antenna could be erected on some vacant land

just beyond the boundary of the space occupied by the umbrella antenna provided this antenna circuit could be fed with power at radio frequency from the power plant. The study of a transmission line that would be suitable for supplying to this antenna from the power plant, 200 kw., at frequencies of around 18,000 per sec. with little loss on the line, disclosed that this was quite practical. The antenna has been erected, this high-frequency line has been installed and the circuit has been operated very satisfactorily now for over a year. The power delivered to the antenna circuit is 92 per cent of the power supplied to the line.

The success of this type of antenna feed circuit will have a profound effect upon the design of stations operating two or more antenna circuits simultaneously.

Grounding System

The first decision to be made in the development of the ground system was whether it should be of the buried wire type, or the type known as "counterpoise" or "earth screen." The New Brunswick station has a ground system combining counterpoise and buried wires. Experience had shown that while the counterpoise type might be ideal, from a theoretical point of view, it would be undesirable from the point of view of practical maintenance.

Fig. 4

A counterpoise consists of a network of wires mounted on poles. These wires carry fairly high potential and the failure of any one wire will cause interruption of service until the fault is located and repaired. The overhead system of wires is also undesirable because it is an obstruction, making the maintenance of the overhead antenna wiring difficult and expensive. Theoretical considerations indicated that a buried wire system would be as effective as an insulated counterpoise provided that its dimensions and design were carefully planned with reference to the character of the soil.

To determine the basic factors for the design of a buried ground system, measurements were made of wave propagation on wires of different lengths buried in the Long Island soil. As a result it was found that the velocity of wave propagation on a wire in this soil is about one-tenth of the velocity of wires suspended in the air. It was found, furthermore, that the resistance of the wire is a function of the wavelength. With increasing length of the wire, the conductivity increases as a linear function up to a length of one-quarter wavelength, where it reaches a maximum, after which it becomes a periodic function of the wavelength and the length of the wire. The results of these measurements showed that the maximum length of wire which could be used effectively must be something less than one-quarter wavelength of the wave propagation in the buried wire.

Measurements of wave propagation in the buried wires indicated that while lengths as great as 1200 feet could be used economically in the Long Island soil, it was furthermore determined, through calculations of the electric field distribution around the antenna, that 76 per cent of the electric lines of force radiating from the antenna would be collected by these ground wires if they were made 1000 feet long. One thousand feet on each side of the center line of the antenna was therefore considered sufficient; the result is that the Long Island antenna, in effect, stands on a plate of copper 2000 feet wide and 3 miles long, and therefore the functioning of this antenna is made independent of the resistance of the soil.

The combined antenna and ground system offers a total equivalent resistance to the antenna currents of only 40 hundredths of an ohm, made up as follows:

Radiation resistance........	0.05 ohms at 16,500 meters
Ground resistance.........	0.10 ohms
Tuning coil resistance......	0.15 ohms
Conductor resistance.......	0.05 ohms
Insulator and other losses..	0.05 ohms
Total....	0.40 ohms

The unit is operated with 200 kw. in the antenna, and the antenna current is 700 amperes, resulting in a radiation of 60,000 meter amperes.

A special plow was constructed by which the wires could be laid cheaply. The plow carried a coil of wire. It had a blade which introduced the wire in the ground at a depth of twenty inches. The plow was drawn by two Ford tractors.

The ground network consists of wires each 2000 feet long buried in the ground a depth of 15 to 20 inches in lines at right angles to the line of the antenna with the center point of the ground wire under the center line of the antenna. The ground wires are spaced 10 feet apart and as the antenna is 7500 feet long there are therefore 750 such wires making the total length of buried wire approximately 1,500,000 feet. The ground wires are connected to a heavy underground bus which runs in the ground under the center line of the antenna. There is also an aerial bus feeder which is connected

to the buried bus through inductive reactances in such a manner as to make all paths to ground of equal reactance, resulting in equal distribution of the antenna current to all sections of the ground system.

Constancy of Wavelengths

A factor of great importance is that of maintaining the frequency or wavelength radiated absolutely constant for reasons that will be referred to later. In radio stations using high-frequency generators of the alternator type the speed of the alternator determines the frequency of the waves radiated. In many other forms of transmitters the frequency is affected by the antenna constants if not actually controlled by the antenna, with the result that as the antenna wires are blown about by wind; and ground and insulators are affected by dry, wet or frosty weather; changes in frequency will constantly occur. In the case of the alternator the problem resolves itself into maintaining the driving motor at constant speed regardless of voltage or frequency fluctuations in the power supply or the telegraph load fluctuations to which it is subjected by the alternator. This is accomplished by a system of relays operated in synchronism with the telegraph key by means of which the voltage applied to the motor terminals and the resistance in series with the wound rotor is varied so that the motor torque is always just equal to the load to which it is applied. Tendency to change speed on account of the telegraph load is thereby eliminated. Speed fluctuations due to changes in the power supply are not so easily disposed of however. A portion of the generator output is utilized to energize a tuned circuit of low resistance adjusted to have a natural period slightly different from the frequency at which the generator is maintained so that if the alternator frequency varies only a few hundreths of one per cent in one direction, there will be a large increase in the current in this resonant circuit, or if the variation is in the other direction, there will be a correspondingly large decrease. A portion of the current in this resonant circuit is rectified and we are thus provided with a direct current which varies up or down practically instantaneously with the slightest change in the alternator frequency. This direct current is made to control the voltage supplied to the motor terminals reducing the voltage to counterbalance a tendency towards increase in speed and vice versa. In order that there may be a visual indication of what is going on, a recording ammeter is inserted in the rectified current circuit; a fine straight line on the ammeter chart indicates a constant frequency, a thick line indicates small and continuous variations of frequency and so forth. Under usual conditions of operation, irregularities of the ammeter chart line can be included within two parallel lines 1/8 in. apart representing maximum frequency variations not exceeding one in 5000 or 4 cycles per second, or 3 meters when operating at 20,000 cycles and 15,000 meters.

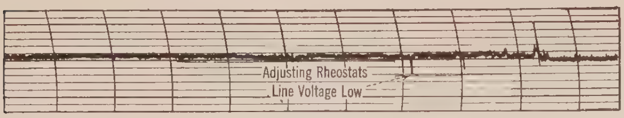


Fig. 5
New Brunswick, N. J.

Fig. 5 is a section of speed control ammeter chart from the New Brunswick station; the irregularities in this chart are due to various adjustments being made while in operation.

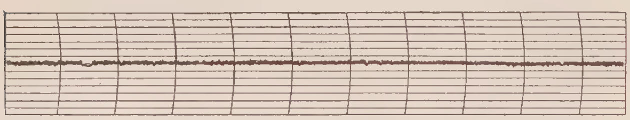


Fig. 6
Radio Central, Long Island.

Fig. 6 is a section from a Speed Control Ammeter chart for one of the transmitters at the Radio Central Station.

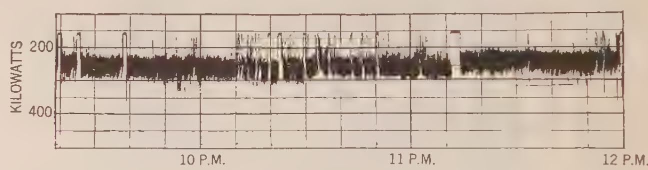


Fig. 7

Fig. 7 is the corresponding section of the wattmeter chart of the same transmitter.

Receiving System

The centralized receiving system is located at Riverhead, Long Island. The antenna is of a new type which gives uni-directional reception. This system is so oriented as to receive signals from the over-ocean transmitter and annul signals from all other directions, including the powerful home transmitter nearby.

The antenna consists of two copper wires strung on ordinary poles like a telephone line, and extending over a distance of nine miles, (15,000 meters). This antenna feeds a number of separate receiving circuits of different wave lengths without the slightest mutual interference or weakening of the signals.

Important as it is, from the point of view of centralization, to be able to receive an indefinite number of signals from the same antenna, the greatest importance in the use of this new receiving system is its remarkable properties of suppressing atmospheric disturbances or the so-called "static" which hitherto has been the bane of radio communication. The attainment of these results is not an accident; it is the result of development work covering a number of years. The "wave antenna" as now used in Riverhead, is the practical answer to the receiving problem of today. The principle of directive

reception has almost unlimited possibilities, and, by economic laws, the receiving system should be developed along these lines until its cost begins to equal the transmitting system. Then will the total cost of a complete circuit, transmitter and receiver, reach its ultimate minimum. However, this economic balance is far from reached as yet. The principles of reception by long antennas were laid down in two papers presented to the A. I. E. E. in 1919, one by Weagant describing a system of balanced long loops, and the other by Alexanderson describing a system of open wires balanced against each other.

In this development the controlling idea is a mental picture which we now have of the nature of the disturbance which we wish to suppress. We call it "static" because it was assumed, in the past, that it was of the nature of static electricity. The hypothesis which is the basis of our modern work is, however, different. We imagine the ether as a disturbed ocean with waves of every length rolling in from all directions. These waves are of the same nature as the signal waves. Those disturbing waves which are of different wave length from our signals, can be shut out by the same means as we use for shutting out other signals; that is, by tuning. But the disturbing waves which have the same wave length as our signal and are in all respects of the same nature, pass through our tuning system like the signal. We must therefore find some basis for discrimination other than wave length.

If we can construct a receiver which is sensitive only to waves coming from one direction, then we can shut out waves from all other directions, even if they have the same wave length. This idea started us on the work of directive reception. Theoretically, there is no limit to the improvement attainable in this direction. We might build a receiving antenna focussed on one transmitting station in Europe, but such receiving antenna would cover a very large area.

A complete theoretical analysis of the wave antenna has been given in a recent paper read this year before the A. I. E. E. by Messrs. Beverage, Rice and Kellogg. For those who wish only to understand the characteristics of our modern receiving system, in order to make use of it, the following popular explanation may be of some guidance.

Imagine the antenna to be a long, narrow lake, and that the wind is the incoming signal, and further that a cork, floating on the waves of water that beat against the shore is the detector. If the observer stands at one end of the lake, he will observe waves beating against his shore only when the wind blows lengthwise to the lake and from the end opposite to this location. When, on the other hand, the wind blows from his end of the lake, the beating waves appear at the opposite end, while his shore is calm. This, at least, would be the case if the lake has smooth sand beaches on which the waves could spend their energy without reflection. But, if the lake ends have steep rocky shores, the water waves will be reflected back and forth and thereby make the surface of the whole lake rough. The waves, which indicate the "signal wind," would thus appear at both ends of the lake, regardless of the longitudinal direction of the wind. This reflection must be avoided. The wave antenna is therefore made with ends corresponding to the sandy beach. The antenna terminates in a resistance which is carefully adjusted to absorb all wave energy and reflect none. The practical advantages of the use of the wave antenna are the elimination of about 90 per cent of the extraneous disturbances known as static.

A valuable practical feature of the form in which the wave antenna has been developed is the method of reflecting the signal so that the "surge resistance" which absorbs the static can be located in the receiving building. This is accomplished by erecting a two-wire line and making the same two wires function both as an antenna and as a transmission line for radio frequency waves. The two wires in parallel act as the antenna. At the far end of the line they are connected together through the primary winding of a special transformer. One end of the secondary of this transformer is connected to the middle point of the primary winding; the other end in connected to ground. The secondary winding feeds the current back into the two wires in series as a transmission line and a second transformer at the front end of the line couples the transmission line to the receiving set. The midpoint of the transformer winding connected to the lines is grounded through the "surge resistance." By this connection, the windings on the two halves of the transformer are opposed for currents flowing over the two wires in parallel, that is, for the antenna effect, and produce no effect upon the receiver.

The resultant reception characteristic curve shows that reception residuals of static of a few per cent may occur in certain directions in the back area of the diagram. The residuals are practically negligible in most cases, but when there is very strong interference or strong sharply directional static in their general direction, an appreciable improvement may be obtained by balancing the residuals to absolute zero for some particular direction in the back area. This is illustrated by Fig. 8.

The final balancing of static and interference is accomplished by the use of an artificial line. This line is fed by currents coming from only the same direction as the undesirable residuals. The phase of these currents may be made anything desired with respect to the phase of the residuals in the secondary of the transformer to which the surge resistance is connected. By making the intensity of the voltage on the artificial line the same as the residual voltage intensity, and by making the phase displacement 180 degrees, the residual currents are readily balanced for any particular direction in the back area.

With this antenna system, extremely satisfactory multiplex reception is being carried out at Riverhead.

Six sets of receiving equipment are normally coupled to this one antenna system, and the signals on six transoceanic circuits are separated by tuning, and copied simultaneously, each independent of the electrical operation of the other sets.

For this purpose, the antenna output transformer is built with several secondaries and the artificial lines are made up to accommodate a number of receiver sets. Many precautions are necessary in the design and arrangement of the receiving equipment to eliminate cross talk and "beat note" interference between the different sets. With this end in view, the equipment for reception of long waves has been completely remodelled.

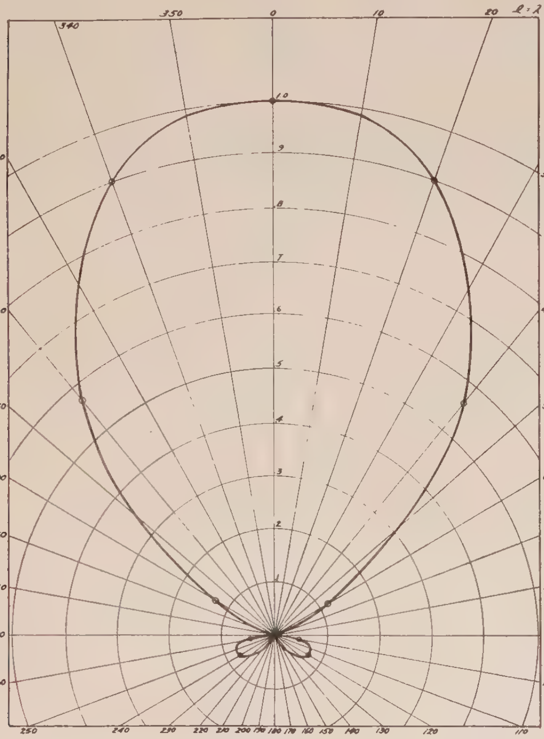


Fig. 8—Directive Curve of Wave Antenna

In the first place, all of the different elements in each receiving set must be thoroughly shielded. The tuning inductances are all balanced pairs of coils placed in an inner shielding of copper to eliminate the losses in the iron casing of the outer shield. In spite of the shielding, cross talk and beat note interference occurred until suitable chokes and filters were placed in both the positive filament and positive plate leads of all coupling tubes, amplifiers, detectors, and oscillators.

The receiving apparatus is arranged in line, with the antenna input panel at one end and the audio frequency output panel at the other end. The intervening units are placed in correct sequence so that the signal currents pass in progressive order along the line through all the various units from input to output panel without looping back over this same path.

The elements of a set are mounted on a sub-panel which is placed in an iron box, the front door of which may be opened. All adjustments of tuning and filament control which are likely to be made frequently on a set tuned to a fixed wave length can readily be made without opening the front door of the iron boxes because such control handles are mounted on the outer doors in such a manner as to engage with the controls on the sub-panel when the iron door is closed.

These receivers are set up on racks holding three sets per rack. Each set is arranged as a complete unit on a shelf and the shelves are arranged in three tiers on the racks. The Riverhead station is equipped with three racks making space for the accommodation of nine receiving sets.

Fig. 9 gives the general view of the receiving equipment.

The signals received from the wave antenna are strong; so usually a total of four stages of amplification is sufficient to bring the intensity of normal European signals up to a strength that is rather uncomfortable to the ear.

Since all the local long wave stations, except Marion, are either behind or in the case of Rocky Point, at right angles, to the direction from which the European signals come, directive reception alone lowers the intensity of the local stations so much that tuning can easily eliminate their interference. Interference as strong for instance, as that from Marion, can be eliminated when the wavelength differs by not less than 3 per cent. For interference of considerably less intensity than that from Marion, as for instance, that from stations in Europe, or from a local station, reduced by directive reception, a 2 per cent difference in wavelength is sufficient.

Fig. 9

For wavelength difference of 2 per cent and less the constancy of frequency of the transmitting station becomes of very great importance. Extremely good frequency regulation at the transmitting station will allow the use of filter circuits by means of which interference on wavelengths differing less than 2 per cent from that of the desired signal can be eliminated.

The receiving station at Riverhead, L. I., is about 70 miles east of New York and the next phase of the

problem was the automatic transfer of the radio signals to the central control office in New York City in order to eliminate the double handling of traffic, the slowing up of the circuit, and the other delays inseparable from the older system. The requirements of this circuit were studied and then the American Tel. & Tel. Co. was requested to provide a suitable tone circuit from Riverhead to our Broad Street office, New York City. For a period of several months experiments were conducted over this temporary line, during which it was demonstrated that it was feasible to send these tone signals over a 70-mile circuit without detriment to the readability of the signals. Continuous commercial operation over a single tone circuit was started about July 1st, 1921. Subsequently additional tone circuits were built for the commercial operation and control of Riverhead station in this manner.

Central Operating Room

The operating room at the city offices is the place where the written message is converted to the dot and dash of the Morse code. The continental code is used in radio as in all other international telegraphic communication. During the last few years a great change has taken place in the transmission of the message. Whereas formerly the manually operated telegraph key was used almost universally for speeds of transmission of 40 words per minute or less, this has been entirely displaced by the machine transmitter. The advantages of machine transmission over hand transmission are (1) that the operator is required to work a typewriter keyboard only and need not necessarily be a skilled telegraphist, (2) that one operator can transmit messages in this manner at rates up to 100 words per minute, whereas the best that can be done by hand is 35 or 40 words per minute, (3) that all characters are perfectly formed and do not vary with the different operators, and (4) the machine is tireless and has no lost time. The telegraphic manipulation is actually accomplished by first punching the message on a paper tape and subsequently passing the punched paper tape through the mechanical transmitter which is an automatically operated telegraph key.

The transmitter sends telegraph impulses over the control wires between the city office and the transmitting station and operates the relay system at that station.

In order that a check can be kept on the performance of the automatic transmitter, the control wires, and the relay system of the transmitting station, a radio receiving set is provided at the city office which makes audible or visible to the operator the actual signal being transmitted into the ether. This receiver is a very simple piece of apparatus, since the reception of the signal from the nearby high power transmitter is not at all difficult, although of course, as there are so many transmitters operating in one locality with only small wavelength separation, very efficient tuning equipment must be provided.

The reception of a message at the city office requires a reversal of the above process. The signal as received at the receiving station is in the form of audio frequency current, the frequency of which is variable as desired, these signal currents are transferred to the city office by telephone wires. At the city office it is necessary to further amplify the currents before they are introduced into the telephone or the recorder. It is possible to use aural reception at speeds up to 35 or 40 words per minute. Better speeds can be secured at times by a combination of aural and recorder reception. At speeds over 40 words per minute tape reception must be used exclusively. It is possible for some tape readers to copy as fast as 60 words per minute but generally for speeds over 40 words per minute; the work is divided up among an increased number of operators; 40 to 70 words per minute two operators; 70 to 100 words per minute three operators, and so forth. The development of the tape recorder used for transoceanic radio reception was ably described in a paper presented to the Inst. of Radio Engineers by J. Weinberger in 1921.

The electrical equipment of the operating room of a city office, handling a large number of circuits, requires careful planning. In the city office of the Radio Corporation of America at 64 Broad Street, New York City, there are at present in continuous operation,

6 transoceanic receivers
6 local Monitor receivers
6 automatic transmitters

and over 30 land wires. To these will soon be added a number of new services.

Power supplies of different types are provided for the various electrical and mechanical devices and measures have been taken to prevent inductive interference effects between instruments.

Wavelength Distribution

The economical wavelength for communication over a certain distance can be selected by the practical rule that the economic range of a station for reliable communication is about 500 to 1000 times the wavelength. If too short a wave is selected the signals will be weak in daytime and strong but variable at night. This variation is most noticeable during the period when darkness exists over the area between the communicating stations. In some parts of the world it is possible to use short waves to advantage because the absorption is comparatively lower than on long waves and variations are unimportant but generally speaking for distances over 3000 miles the reliability of wavelengths of over 11,000 meters is so much greater than that of shorter waves. Long waves have therefore been universally adopted for long distance communication.

It can now be readily seen that since the ability to receive distinct signals depends on the separation of different frequencies there is a definite limit to the number of "channels" of communication between stations that can be set up.

If the wavelengths between 11,000 and 22,000 meters are divided into 2 per cent bands there are 35 "channels." If into 1 per cent bands, there are 70 "channels." Except to such extent as directional reception will permit the number of one way channels open for such, long distance communication is limited to the number of these bands.

If we suppose our plans to be based on the use of 1 per cent bands, it is evidently necessary first that each transmitter shall cause no radiation outside of the 1 per cent band allotted to it and furthermore shall maintain its actual radiation frequency exactly on the center of such band; and second that each receiver shall be capable of separation of currents from those differing only 1 per cent in frequency. The above requirements imposed upon the transmitter have already been proved practicable. But the realization of the full possibilities of radio communication requires that all transmitters of antiquated type which take undue space in the ether be replaced.

There are, however, other difficulties that cannot be so easily overcome. For instance while it is quite possible for the receiving station to separate currents of frequencies differing 1 per cent if the voltages induced at the station at the different frequencies are equal, it is not an easy matter to separate the currents when the voltage induced in one case is 1000 times the voltage induced in the other. This is the situation where in the case of a transatlantic circuit the receiving station in America receives from Europe on 15,000 meters and the transmitting station in America sends to Europe at the same time on 15,150 meters. In such cases, as described above, it is necessary to increase the separation between frequencies to 3 per cent and in order that such large separation may not be too numerous a rule has been established by precedence and informal agreement, that all the transmitters in one locality shall transmit on wavelengths close together. We have such a case in the concentration of American transmitters between 16,000 and 17,500 meters. In this band of wavelengths there are operating at present the following stations:

15,900 Meters	Tuckerton No. 1 Transmitter
16,300 Meters	Kahuku No. 1 Transmitter
16,465 Meters	Radio Central No. 1 Transmitter
16,700 Meters	Tuckerton No. 2 Transmitter
16,975 Meters	Kahuku No. 2 Transmitter
16,975 Meters	Annapolis Compensating Wave Arc
17,145 Meters	Annapolis Signalling Wave Arc
17,500 Meters	Radio Central No. 2 Transmitter

It is planned to operate transmitters in Sweden, Poland and Argentine in the near future on wavelengths 18,000 meters to 19,000.

The French Government station at Lyon operates at 15,500 meters and there are a number of additional European and American Transmitters operating between that wavelength and 11,000 meters, while other Government and Commercial stations in France are at present operating at wavelengths from 19,000 to 22,000 meters.

The congestion of the ether is therefore not a mere matter of looking into the future, but a real present day problem. The necessity for traffic regulation is at least enough to prevent reckless driving so to speak, is just as apparent as the undesirability of hidebound regulations until such time as the limit of possible improvements in technique have been more definitely determined.

Such is the present situation in the long distance radio ether. The congestion is due to the necessity for the use of the longer waves for long distance work and the fact that all high-power stations are broadcast stations; much improvement is possible in existing practise but radically new methods of operation must also be considered, such for example as directional radiation on shorter waves. With the realization of such possibilities the situation will take on a new aspect.

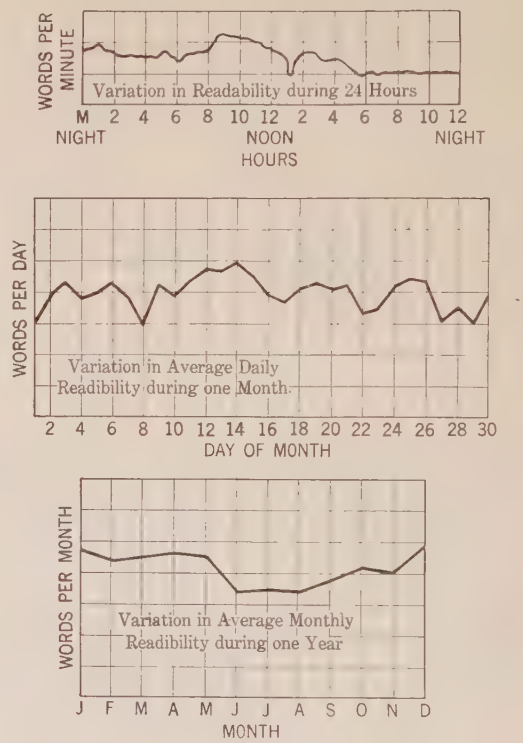


Fig. 10

Project of New Communications

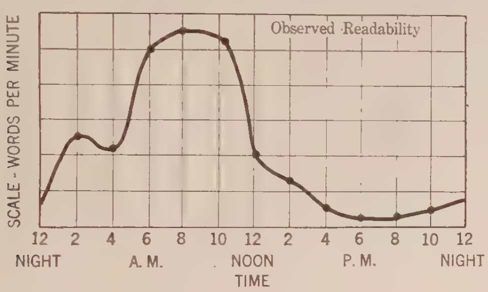
Sufficient statistics are now available by means of which the technical and financial possibilities of new circuits of communication can be accurately predetermined.

Fig. 10 shows the daily, monthly and yearly reception curves for a typical transatlantic circuit. The ordinates of these curves show the capacity of the circuit at the different times of the day and year respectively. By the capacity of the circuit we mean the practically possible speed of reception in five-letter code words per

minute. The capacity of the circuit is a function of the strength of the signal and the intensity of the disturbance. The intensity of the signal is measured in absolute units of microvolts per meter.

Experience has shown that under any given condition of atmospheric disturbance, there is a direct proportionality between the strength of the signal measured in microvolts per meter and the traffic capacity of the circuit measured in words per minute. The proportionality defined above is almost exact between the limits of oral reception ranging from 5 to 40 words per minute and it can be considered as substantially correct up to the highest speeds that are used. This simple relation between strength of signal and words per minute has given us a practical method of measuring the intensity of atmospheric disturbances.

As an actual standard method of measurement an artificial signal is introduced into the receiving system and regulated so that the capacity of the receiver is 20 words per minute. The number of microvolts per



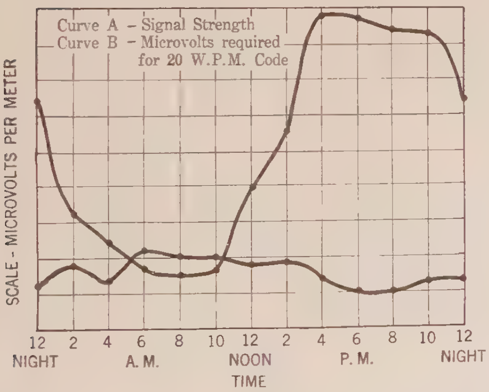


Fig. 11—Typical Daily Variation of Signal and Disturbances on Vertical Antenna During Summer Months at Belmar, N. J.

meter which must be introduced to permit reception at 20 words per minute is thus a direct measure of the intensity of disturbance.

Fig. 11 shows a typical daily curve of variation of signal strength and disturbance, measured on a simple vertical antenna.

If a transmitting station is to be designed for a new geographic location, measurements of disturbances are taken in that location. The results of these measurements, which may be taken over a large part of a year, show what strength of signal will be needed during the different months of the year to carry a desired traffic. Fig. 12 shows a typical chart of this kind. Comparison between this chart and the known typical yearly chart for a transatlantic circuit gives a direct indication of the capacity of the new circuit in terms of the circuit in operation. The chart for the projected circuit shows the capacity of a 50,000-meter ampere and of a 100,000-meter ampere transmitting station.

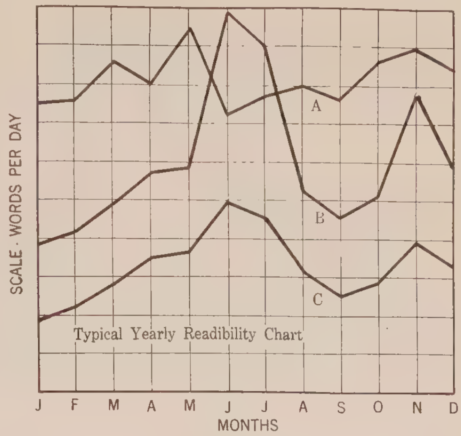


Fig. 12

Curve A — Typical East-West circuit.
Curve B — Typical North-South circuit. Calculated for 100,000 M.A.
Curve C — Typical North-South circuit. Calculated for 50,000 M. A.

Thus it can be stated that guess work has been eliminated from the development of radio communication, and that sound foundations, both technically and financially, can be laid for all future expansions of our system.

IMPURITIES IN STORAGE BATTERY ELECTROLYTES

The importance of obtaining information concerning the action of impurities in storage battery electrolytes arises from the detrimental effects which many of them produce on the operating characteristics and life of the storage battery. Such information is necessary as a basis for the preparation of specifications covering sulphuric acid for use in batteries. A new method of measuring the rate of sulphation of storage battery plates was recently devised at the Bureau of Standards. The same method and apparatus have been employed in the present investigation with some modifications, and the effects of small amounts of iron, manganese, platinum, and copper have been determined. It was found that the presence of 1 part in 10,000,000 of platinum in the electrolyte increases the local action at the negative plates 50 per cent; the effect of copper is much less, while the effect of iron is of unusual interest because of its accelerating action at the negative plates. Manganese deposits upon the positive plates in the form of manganese dioxide which covers the active material, closes the pores, and causes a large amount of charging current to be wasted as gas. Work is being extended to include the effect of other impurities.

Desirable Duplication and Safeguarding in the Electrical Equipment of a Generating Station

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Review of the Subject.—The question of how far to go with duplication of equipment and the installation of safeguards is one that plays an important part in central station design. The extent to which these provisions are made has an important bearing on the cost of installation and has a direct influence upon the dependability of the service rendered. Stations on larger interconnected systems require a greater degree of protection of this nature than is usually the case in stations on small systems on account of the importance of the service as well as the more serious results of short circuits, due to the greater concentration of energy.

This article discusses the more important considerations to be taken into account and points out that local conditions will have a determining influence on the decision made.

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IN order to provide against serious interruptions to service, adequate safeguards must be provided in the installation of electrical equipment in generating stations. Also, to permit equipment to be taken out of service for inspection and repair without interfering with the continuity of the service, certain portions of the apparatus and connections must be duplicated. To what extent duplication should be carried is one of the important questions that concern central station design.

The importance and the character of the service given have a direct bearing on this question, and in stations of large metropolitan systems it is of course necessary to provide against interruptions to a much greater extent than would be the case in smaller and less important stations. In determining how far these provisions should be carried, the probability of trouble and the value of the added safeguards and extra apparatus required must be carefully balanced against the greater cost of installation and the increased complications that may be involved in the design. Simplicity of operation should always be striven for.

Experience in the design and operation of large stations shows that certain features of this nature are of the greatest importance. The arrangement of busses is one of these and it requires most careful consideration. The bus layout should provide for two sets of main busses, preferably connected through reactors with provision for connecting any generator to either bus and each bus sectionalized so that trouble may be isolated; or else it should be a ring bus system with sections connected through reactors. In either case the installation of reactors of the requisite value to limit the short-circuit current in any section to an amount within the safe rupturing capacity of the switching equipment is essential to safe operation.

The isolated phase arrangement of the busses in the switch house, which eliminates the danger of phase-to-phase short circuits within the station, together with generator neutral resistances of such value as to limit the current to ground to a reasonable amount, affords a high degree of safety. In stations of large capacity this arrangement is particularly desirable.

Presented at the Annual Convention of the A. I. E. E., Swampscott, Mass., June 26-29, 1923.

In addition to the foregoing, an amount of duplication of bus construction sufficient to enable any part of the installation to be disconnected from the system for inspection or repair, without interfering with service, is necessary. Grouping of lines on separate line busses, which may, as a unit be connected to either of two main busses, is an effective form of duplication that is commonly used. With parallel lines to the same substation connected to different line busses, a very flexible arrangement may be secured without unduly increasing the number of switches.

The installation of current-limiting reactors on all outgoing lines is now recognized as necessary to reduce the effects of short circuits due to cable breakdowns. A further safeguard, in addition to an adequate system of relays on the lines themselves, is the installation of relays with a long time setting on the group switches between the main busses and the line busses.

All practical precautions should be taken to prevent any interruption to the supply of energy to the control system. The use of a storage battery of ample capacity with duplicate charging sets gives a high degree of reliability and freedom from interruption. The control system should be well sectionalized to permit the necessary testing and the isolation of any portion that has developed a ground or other trouble. Important parts of this system should be duplicated and throw over switches provided. Particular care should be given to its design and installation, and it should be so installed that it will be able to withstand a test of at least 1500 volts to ground.

As the reliability of the excitation system is one of the most important conditions required, duplication of supply and thorough safeguarding of the system are necessary. If shaft-driven exciters are used, some form of reserve excitation, with throw-over switches to it should be provided. This reserve may be a separate exciter, a battery, or both. As shaft driven exciters are usually designed with an extra factor of safety, both mechanical and electrical, the comparatively high additional investment in reserve excitation storage battery may not be warranted. In such cases, it is the practise to connect the operating bus battery so that it may, in emergency, be used for excitation. When this

is done, the battery should be of sufficient capacity to carry the load of the control system and the excitation of the largest generator in the station without exceeding its normal one-hour discharge rate. If the excitation is obtained from separately driven exciters, a total capacity of exciters sufficient for supplying the excitation of all units, with one spare exciter will be required. Duplicate exciter busses are necessary with this system to insure adequate reliability.

Temperature detectors imbedded in the generator windings, with suitable indicating and recording instruments are a very important safeguard. The number of these to be installed in a generator should include extra detectors for use in case any of the others become open-circuited.

The installation of duplicate synchroscopes is extremely desirable, as it is necessary to be able to synchronize at any time.

Of particular importance is the safeguarding of the auxiliaries, which are now so largely electrically driven, as the operation of the main units is absolutely dependent upon the continuous service of certain of these auxiliaries. Any reasonable amount of duplication and safeguarding required to obtain this condition is not only justified, but necessary. Reliability of the source of supply is the first requisite, but the same degree of "standard practise" has not as yet been reached in the installation of the auxiliary power system as has been the case in other parts of station design. A house generator, which is not affected by system trouble, would afford a high degree of reliability of supply. If connected in parallel with transformers fed from the station bus, with a dependable method of automatically throwing the essential auxiliary motors to either source, in the event of trouble on the other, the chance of failure of supply is reduced to a minimum.

If a house generator is not used, it is necessary to depend upon supply from the station busses through transformers. In addition to the number of transformers necessary to carry the station auxiliary load, an additional transformer of each voltage should be installed, ready for immediate use in the event of a burn-out of any of the others. In order to minimize the effect of system trouble, a method of connecting the source of supply for the auxiliary transformers to each of the main busses, with reactors between each bus and the point of connection, has been used. The effect of trouble on either bus section is then less liable to lower the voltage of the auxiliary power system to a value that would seriously affect the operation of the motors. A system of relays designed to disconnect the auxiliary systems from the bus section that may be in trouble is an essential feature of this scheme.

Duplication and sectionalizing of auxiliary power busses, with throw-over switches in the motor services, or emergency services to which the motors could be connected when trouble occurs on this part of the auxiliary system, would insure reasonable reliability of service.

In conclusion, the degree of refinement to which duplication and safeguarding should be carried, depends to some extent upon the circumstances existing in each individual case. The features which have been discussed should all be taken into account and modified as may be necessary to meet local conditions.

TO ELECTRIFY RURAL AMERICA

There are about two thirds as many farms in the United States today as there are wired residences. Less than 10 per cent of these farms are now electrically lighted.

The lighting of these homes is, of course, intimately connected with the supply of electricity to the farms either by small home lighting plants or by the extension of central station service. The conveniences of central station service has raised a rather insistent demand for it on the part of the farms within possible reach of it and in many sections farmers have refused to purchase small plants in the hope that within a few years they may be able to obtain central station service. Some central stations have found themselves under considerable pressure to extend their lines beyond the point where, because of the relatively small use made of electricity on each farm and the expense involved in extending lines for great distances, service can now be rendered economically.

If the farms would, in addition to its use for lighting and the operation of home appliances, employ electric power to replace that now produced manually, and by gas engine, horses, and windmills, the central stations could economically extend their service lines to cover a much greater territory than what is now warranted and this would, of course, immediately open up a considerable field for the extension of lighting service.

A joint committee, representing the National Electric Light Association, the American Farm Bureau Federation, the American Society of Agricultural Engineers, and the U. S. Department of Agriculture, has been recently organized to study the extent to which electricity may profitably be employed in agriculture. It held its first meeting in Chicago, March 8, 1923, and outlined the four following investigations and activities to be undertaken under its general supervision:

1. Farm Power Survey.
2. Survey of Central Station and Isolated Plant Service to Farmers.
3. Survey of Agricultural Uses of Electricity in Foreign Countries.
4. Experimental and Research Work on the Uses of Electricity in Agriculture.

As a result of the investigation of this committee, a general movement to extend central station service to all farms within a large territory surrounding the present electrified areas may eventually take place.

Dielectric Strength Ratio Between Alternating and Direct Voltages

BY J. L. R. HAYDEN and W. N. EDDY

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Both of the General Electric Company, Schenectady, N. Y.

Review of the Subject.—*High-Voltage insulation testing has been and is usually still done by alternating voltages.*

High direct voltage was made available for testing purposes by the development of the kenotron tube. When used for testing insulation direct voltage has several advantages over alternating voltage. (1) the power necessary is often much less with direct voltage than with alternating voltage. In apparatus of high electrostatic capacity, such as long high-voltage cables, the size of the alternating-voltage testing transformer becomes excessive, thousands of kilovolt-amperes being necessary. Direct voltages are therefore preferable as they necessitate only a few kilowatts. (2) Excess direct voltage is less likely to permanently damage the insulation than excess alternating voltage. (3) If direct voltage is used conductivity tests can be made and the action of the material on the application of the voltage more thoroughly studied.

As the use of high direct voltage for testing purposes is found to be increasing, it is important to determine the relation between the insulation stress produced by direct and that produced by alternating voltages.

Little is definitely known of what is called the "dielectric strength ratio of insulation" which is the ratio of the direct disruptive voltage to the crest value of the alternating disruptive voltage. In general, this ratio might be expected to be unity. While such is the case with air some engineers have claimed, however, that some solid insulations stand a higher direct than alternating voltage.

Therefore, a very extensive set of investigations was made, with direct and with alternating voltages, on liquid and solid insulations of homogeneous and non-homogeneous structure, over a range of temperature, thickness and rate of voltage application. Their dielectric strength ratios were determined and are given and discussed in the paper.

It was found that the dielectric strength ratio may be greater than unity, and sometimes very much so, that is, that the material may stand higher and sometimes very much higher direct voltages than alternating voltages, but also that the ratio with other materials may be less than unity, that is, the material may stand higher alternating than direct voltages.

Ratios less than unity were given by oils, petrolatum, powdered glass, etc., that is, they stood higher alternating than direct voltage, though the difference rarely exceeded 10 per cent.

Ratios above unity were given by paper, cloth, solid glass and mica, etc., indicating a greater strength for direct than for alternating voltages.

The dielectric strength ratio of some materials, such as laminated paper, was found to vary with the condition and in general increase with decreasing temperature, decreasing thickness and increasing rapidity of voltage application.

Some materials, such as petrolatum impregnated cable paper, gave a very high ratio, some times exceeding two, while the component materials did not differ much from unity, petrolatum being a little below and air-dry paper a little above unity.

It is believed that the observation of the dielectric strength ratio and its changes with the condition of test, will give us a powerful tool for the investigation of insulation, and assist in solving the problem of understanding the mechanism of the breakdown of insulation in an electric field.

CONTENTS

As the operation of electrical apparatus and circuits depends on their insulation, the maintenance and test of insulation is of foremost importance.

Insulation testing, even of direct-current apparatus, is usually done by alternating voltage, since high alternating voltages are easily obtained by the alternating-current transformer.

Two serious disadvantages arose in the use of alternating high potential testing: First, in apparatus of considerable capacitance such as underground cables, the charging current at the high test voltage is excessive, requiring uneconomically large and expensive transformers. Second, in other apparatus, corona and other dielectric losses incident to the abnormally high alternating test voltage (of three and a half and more times the normal operating voltage), may permanently damage the insulation.

With the development of the kenotron vacuum tube as rectifier, high direct voltages became available. As there is no permanent charging current with direct voltage, a kenotron rectifier of a few kw. capacity could replace a testing transformer of many hundred kw. In the absence of the intensive corona and the high dielectric losses incident to an alternating field, damage of apparatus by the high testing voltage was less to be feared with direct voltage testing.

At first it was expected that the striking distance with direct voltage would be equal to that of the maximum value of the alternating voltage, and tests made with air as dielectric corroborated this. However, engineers familiar with high-voltage, direct-current transmission claimed that apparatus could stand materially higher direct voltages than alternating voltages. When high direct voltages became more available, tests made with them showed that some solid insulation, such as that of cables, stand a higher direct voltage than alternating voltage, and it was hoped then that a constant ratio between the disruptive strength

Presented at the Annual Convention of the A. I. E. E., Swampscott, Mass., June 26-29, 1923.

of direct and of alternating voltage could be found, by which the one could be expressed in terms of equality with the other. A series of tests made abroad on cables gave 2.5 as the average ratio between the direct voltage and the (effective or root-mean-square) alternating voltage which has the same disruptive effect.

Further tests made by various engineers here and abroad gave inconsistent results and different ratios between the disruptive effect of direct and alternating voltage, so that now no fixed ratio between direct and alternating voltage can be universally applied.

As the result of several years experimental investigation we have come to the conclusion, and expect to show in the following, that:

1. The disruptive effect on insulation of a direct voltage in general is different from that of an alternating voltage of a peak value equal to the direct voltage.

2. The puncture or disruptive effect of the alternating voltage (peak value) may be greater, and sometimes very much greater, than that of the direct voltage of equal value, but it may also be less. That is, the ratio: "Direct voltage divided by the peak value of the alternating voltage which gives the same disruptive effect", which we may call "dielectric-strength ratio", varies from values less than unity, when the direct voltage stress is more severe, to values much above unity, when the alternating voltage stress is more severe.

3. In air, the dielectric-strength-ratio is probably unity.

4. In solid insulation, the dielectric-strength ratio depends on the mechanical, physical, and thermal conditions of the material, and in general, seems to tend towards unity, the more homogeneous the material is.

5. In one and the same material, the dielectric-strength-ratio may vary considerably with temperature, thickness, rate of voltage application, etc.

6. In general, it seems that the mechanism of failure of insulation under high alternating voltage stress is materially different in some features from that under high direct voltage stress, and no universal and constant dielectric-strength-ratio can therefore be expected, but dependent on the feature which dominates in the failure different values must result.

The dielectric-strength ratio has been defined in the previous literature in two ways, either as the ratio: Direct voltage divided by effective or root-mean-square value of alternating voltage (in which case air would have the ratio $\sqrt{2} = 1.41$) or otherwise the ratio: Direct voltage divided by the peak value of alternating voltage, which gives to air the convenient ratio 1. We use herein, and recommend for general acceptance, the latter definition, as more rational. It gives the value 1 to air, and in general the values tend toward 1, and it gives the value 1, if the nature of the alternating voltage puncture is the same as that of the direct voltage puncture, since a direct voltage and an alternating voltage with the same peak value, should be equivalent.

Although the values given in the following tables are the averages and abstracted from thousands of individual tests, made under the greatest possible precautions, so that the experimental errors are small, they are not so consistent as to draw final conclusions from single recorded values (though these values usually are averages of 10 or 25 tests), and the conclusions are drawn from the general trend of groups of individual values. The reason for variations in results is the inherently erratic nature of disruptive tests. Dielectric tests made with air can be duplicated within two to three per cent, but in liquids like oil erratic variations occur between successive tests made with all precautions, amounting to 20 per cent to 30 per cent and more.[1] In solid insulation, the phenomenon of dielectric disruption apparently is still more complex, and the individual test results therefore are still more erratic, so that acceptable conclusions can be drawn only from the comparison of the averages of very numerous tests.

The results of this investigation seem inevitably to lead to the conclusion that the dielectric rupture under high-voltage stress is a far more complex phenomenon than is usually assumed. Puncture is not due to a mere effect of electrostatic stress, or a mere heating effect, or any specific deterioration effect, etc., but it results from a number of different effects combined in different degrees. While it is somewhat disappointing no universal "dielectric strength ratio" can be determined, which is applicable to all conditions and all apparatus, we believe that dielectric-strength-ratios can be derived for definite classes of insulation under definite operating conditions, and that the determination and study of the dielectric strength-ratio will give us an additional and powerful tool in the study of insulation failure and its causes.

Methods of Tests and Apparatus

The principal source of high, direct voltage used in the tests was the kenotron. This is a two-element vacuum tube containing a filament cathode supported within a cylindrical plate as anode. The filament is kept incandescent by means of either a transformer or a storage battery. In operation the kenotron acts simply as a unidirectional conductor, passing through only the half waves of one polarity. Fig. 1 shows some of the principal circuits used for kenotron rectification. (a) is the simplest connection. In this the kenotron is in series with the supply transformer and a condenser storing the rectified voltage. This gives a direct current, every second half cycle the vacuum becomes conducting. The principal advantage of such a connection is its simplicity, and if the load is small compared with the condenser capacity, the voltage is quite steady. Diagram (b) shows the bridge type of connection. This has the advantage of passing through both half waves in such a way that they produce the same

1. "Three Thousand Tests on the Dielectric Strength of Oil," by Hayden and Eddy, presented before Convention of A. I. E. E. at Niagara Falls, June 26-30, 1922.

polarity on the receiving circuit. Diagram (c) shows the full wave or double half wave type which has the principal advantage of requiring an alternating voltage source of only approximately one-third of the direct voltage. The purpose of the condenser is to smooth out the pulsations of the direct voltage. It is readily seen that the half wave connection (a) requires more capacitance than a full wave connection either (b) or (c). The capacitance required for satisfactory smoothing is dependent on the load. In testing long cables no capacitance additional to that of the cable is required. But laboratory tests on short lengths of cable or other test pieces of low electrostatic capacity necessitate the use of the condensers shown above. On account of the small direct current conducted by any type of insulation the voltage fluctuation of such a rectifier can be reduced

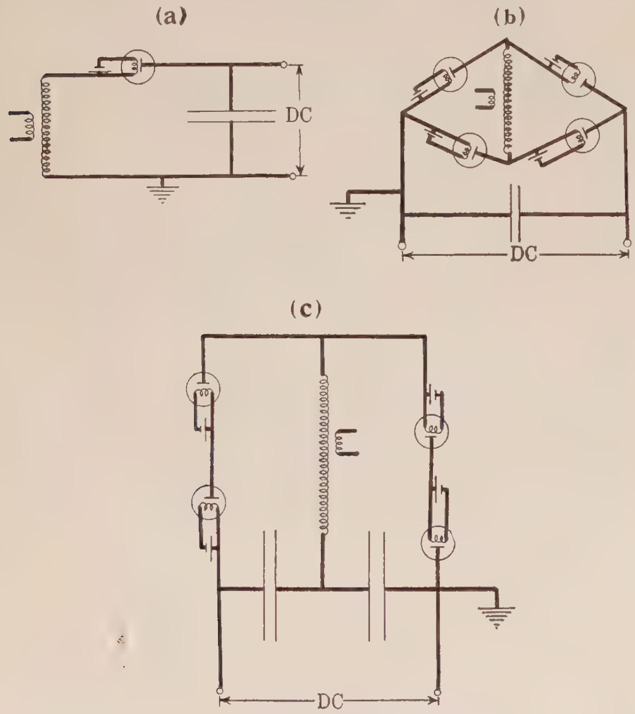

Fig. 1—Kenotron Rectifier Connections

below 2 per cent without the necessary condensers becoming large.

Both the alternating and the direct-voltage data were taken on the same transformer. The direct voltage was obtained by means of the full-wave kenotron connection (c) Fig. 1 described above, using sufficient capacitance in parallel with the sample to reduce the ripples in the voltage wave to less than 2 per cent under the conditions of tests. In taking all spark voltage values special attention was given to the rate of increasing the voltage, keeping this rate as nearly the same as possible at the value noted in the data.

The various types of insulation were tested in various forms and shapes and with various electrodes but care was always taken to have no sharp corners or edges on the electrodes. All voltage readings were taken on the low side of the supply transformer and the high-tension voltage, whether alternating or direct, was obtained from a calibration curve which had been made against a sphere gap in parallel with the sample or an equivalent load. All direct-voltage data below 3000 volts were taken on a special direct-current generator with field control, the voltage being read by an indicating voltmeter in series with multiplying resistance. Whenever possible both alternating and direct voltage punctures were taken on the same sample of insulation. For instance, if the sheet of insulation under test was large enough for 10 puncture tests, 5 would be taken on alternating and 5 on direct voltage. At no time were more than 5 punctures taken on alternating voltage without then taking an equal number on direct voltage or vice versa so as to give the closest possible comparison. Each value, given in the tabulations below, usually is the average of 10 to 25 tests. Practically all of the tests were repeated at different times by different operators and under different experimental conditions.

Results of Tests

A. Oil, Petrolatum and Cable Paper

A series of tests were made on the materials entering the insulation of high-potential cables, such as petrolatum and cable paper, and the results of these tests are given in Table I. In the same table are also given the results with transil oil No. 6, as of similar character to petrolatum but far more fluid. Oil and petrolatum were tested between 2.54 cm. spheres, but cable paper was tested between 5 cm. plates. The alternating voltage values are the maximum of the voltage wave.

The table gives the tested materials: Transil oil No. 6 alone, petrolatum alone, manila paper of 0.2 mm. thickness in air dry condition alone, and the same paper impregnated with petrolatum. The table also gives the length of the gap between the spheres for oil and petrolatum, and the number of layers of cable paper used. Then it gives the approximate rate of voltage increase in per-cent-per-second of the puncture voltage. Then follow the values of direct voltage in kilovolts, and of alternating voltage, peak values for the four temperatures 25 deg., 50 deg., 75 deg. and 100 deg. cent., and finally in the four last columns the values of the "dielectric-strength ratio" derived by dividing the direct voltage by the alternating voltage. As seen, values are given for three rates of increase in terms of the puncture voltage as follows: 20 per cent, 5 per cent and 0.1 per cent rise of this voltage per second. Each of the numerical values given in Table I is the average of a minimum of 10 to 25 observations, but in many cases as many as a hundred repetitions were made.

a. Oil—Its Dielectric-Strength Ratio. The table shows incidentally that the dielectric strength of oil, with direct voltage as well as with alternating voltage, decreases somewhat with increasing temperature, but not to any great extent.

TABLE I
OIL, PETROLATUM AND CABLE PAPER

Material	Electrodes	Length of gap mm.	Rate of voltage rise per cent per sec.	Direct voltage kv				Alternating voltage kv.				Dielectric-strength-ratio			
				25 deg.	50 deg.	75 deg.	100 deg.	25 deg.	50 deg.	75 deg.	100 deg	25 deg.	50 deg.	75 deg.	100 deg.
Transil oil No. 6	2.54 cm. spheres	2	5	30.5	28.8	27.6	19.9	32.9	27.2	27.0	25.3	0.927	1.059	1.022	(0.785)
		4	5	45.8	37.5	36.2	34.0	53.0	45.0	40.4	37.7	0.864	0.833	0.896	0.902
		2	2	20.7		20.5		25.4		19.5		0.815		1.051	
		4	2	36.7		37.0		49.0		42.9		(.755)		0.862	
Petrolatum	2.54 cm. spheres	2	5	15.1	15.6	17.8	15.1	15.9	22.7	18.4	15.9	0.950	(.687)	0.967	0.950
		4	5	27.6		34.8	28.2	28.9		35.9	29.6	0.955		0.969	0.953
		No. of layers													
		4	20	4.3	3.4	3.6	3.2	2.4	2.5	2.3	2.2	1.790	1.360	1.565	1.445
		8	20	9.0	8.4	7.7	7.0	7.0	6.6	5.5	5.5	1.286	1.273	1.400	1.273
		16	20	17.3	12.8	12.7	13.1	16.1	12.0	11.6	9.7	1.075	1.067	1.095	(1.340)
		32	20	33.1	26.6	24.5	26.5	30.5	28.0	28.0	28.0	1.085	0.950	0.875	0 946
Cable Paper 0.2 mm. thick air dry	5 cm. plates	4	5	5.4	4.84	5.47	4.4	4.19	4.15	4.25	4.33	1.290	1.176	1.287	1.016
		8	5	7.6	7.5	8.7	9.0	7.39	7.32	8.97	8.72	1.028	1.025	0.969	1.032
		16	5	14.0	13.0	15.2	15.2	12.8	12.9	13.6	15.3	1.094	1.078	1.117	0.993
		32	5	22.5	13.1	15.3	20.3	18.7	13.2	15.6	20.7	1.203	0.992	0.981	0.981
		4	0.1	5.3	4.7	4.5	4.0	4.5	4.1	4.2	4 0	1.178	1.147	1.072	1.000
		8	0.1	9.2	9.4	7.8	8.3	8.8	7.8	7.8	7.8	1.045	1.205	1.000	1.064
		16	0.1	15.5	13.6	12.7	13.5	16.3	14.7	14.0	14.3	0.951	0.925	0.907	0.944
		32	0.1	27.5	25.5	24.3	22.5	31.5	29.7	28.9	28.3	0.873	0.858	0.841	0.774
		1	20	7.4				3.0				2.470			
		2	20	18.3	19.0	15.0	15.1	6.6	10.6	8.7	7.8	2.775	1.793	1.725	1.940
		4	20	31.0	41.5	39.3	29.5	15.8	25.3	24.6	20.3	1.960	1.635	1.605	1.453
Cable Paper 0.2 mm. thick, impregnated with petrolatum	5 cm. plates	1	5	9.4	8.0	6.7	7.5	7.0	6.5	5.6	6.5	1.343	1.232	1.197	1.154
		2	5	36.0	22.8	17.7	22.4	18.2	15.9	14.3	13.6	1.980	1.435	1.238	1.650
		1	0.1	5.0				3.2				1.565			
		2	0.1	16.2	14.4	13.8	14.7	7.0	7.3	8.0	8.5	2.314	1.975	1.725	1.735
		4	0.1	29.5	36.5	34.0	25.7	15.5	20.3	21.7	20.5	1.900	1.795	1.570	1.253

As would be expected from the erratic behavior of oil, discussed in a previous paper, the values of the dielectric-strength ratio of the oil, given in the last four columns, differ from each other more than any possible error of observation. However, in general the data show fairly conclusively a dielectric-strength ratio somewhat below unity,—specifically a general average of $R = 0.923$. In other words, this ratio of 92 per cent indicates that *oil has a greater dielectric strength under alternating than under direct voltage,* by about 8 per cent.

A Comparison of Ratios at Different Temperatures. The combined averages of all the ratios at 25 deg. and 50 deg. cent. is $R = 0.900$; but the combined averages of all the ratios at 75 deg. and 100 deg. cent. is $R = 0.947$. This change shows that the dielectric-strength ratio increases with increasing temperature or, as we may say, becomes more normal at higher temperatures by approaching closer to the value of unity.

Ratios at Different Gap-Lengths. The average ratio for the short oil gap is $R = 0.975$; the average ratio for the long gap is 0.871. This difference shows conclusively that the dielectric-strength ratio of oil seems to become more abnormal, that is, differs more from unity, with increasing length of oil gap. This conclusion, however, requires further corroboration.

Ratios as Affected by Rate of Increase of Voltage. For the slower rate increase of voltage, 2 per cent per second, the ratio averages $R = 0.909$; for the faster rate of 5 per cent per second it averages $R = 0.929$. The conclusions drawn from this small change of 2 per cent also require further corroboration.

b. Petrolatum—Its Dielectric-Strength Ratio. Petrolatum is stated to be an amorphous hydrocarbon, essentially of the paraffin series. At room temperature it has the consistency of vaseline, and as a closely related hydrocarbon it shows the same general characteristics as transil oil.

As seen from the table, the dielectric strength of petrolatum, under direct or alternating voltage, does not appreciably change with the temperature, between 25 deg. and 100 deg. cent., nor is there appreciable change in the dielectric-strength ratio.

The averages of the dielectric-strength ratio, taken from the table:

At:	25 deg.	75 deg.	100 deg. cent.
$R =$	0.952	0.968	0.952

Thus the ratio is essentially constant.

Again as regards variation in gap-length:

At: 2mm. 4mm. length of gap between spheres: $R =$ 0.956 0.959 respectively, which is also essentially constant over this small range of gap.

The average of all values of dielectric-strength ratio for petrolatum is: $R = 0.957$. Therefrom it is evident petrolatum shares with oil the characteristic that its

dielectric strength is less for direct voltage than for alternating voltage, but the difference is not so great.

If the abnormal behavior of oil were due to differences in the mechanical motion produced in the ingredients of its unhomogeneous structure by the continuous dielectric field, the resultant concentration of the weaker ingredients might account for its lesser strength under the continuous direct voltage than under the alternating voltage stress, and the far more viscous petrolatum would show still less the effect of any movement and concentration--as is, in fact, the case.

c. Dry Unimpregnated Cable Paper—Its Dielectric Strength Ratio. Incidentally tests with direct and alternating voltage show no definite difference in effect on the dielectric strength of cable paper, within the range of temperature, and rate of voltage rise used in the tests. But there is a very pronounced effect on the dielectric-strength ratio, as seen from the three sets of values in the last four columns of the table which tabulate 48 results, each the average of a number of tests. Ratios are given for the three general factors viz., for temperatures from 25 deg. cent. to 100 deg., cent., for thickness from 4 to 32 layers of 0.2 mm. paper, and for rates of voltage rise from 0.1 of 1 per cent per second to 20 per cent per second. Although individual values may fall somewhat out of line, there is a very pronounced grouping of the results. The highest values of dielectric-strength ratio occur at the lowest temperature, at the lowest thickness and at the highest rate of voltage rise (shown in the table at the top left-hand corner). On the contrary, the lowest values of the ratio occur at the highest temperature, the thickest insulation, and the slowest rate of voltage rise (shown at the bottom right-hand corner). It is interesting to note that with dry paper, unlike oil, the ratio extends to both sides of unity. There are some values materially above 1, and there are also values below 1.

To get the general trend of variation of the ratio, with each separate feature, we average all the values for the same temperature, or for the same thickness, or for the same rate of voltage rise, and thus get the effect of one variable, segregated from the effect of the others. This grouping of data gives the results recorded below.

Temperature, Thickness, and Rate Data for Dry Unimpregnated Cable Paper.

Temperature:	25 deg.	50 deg.	75 deg.	100 deg.
Average ratio: R =	1.158	1.088	1.092	1.057

There is a consistent decrease of ratio with increasing temperature.

Thickness:	4	8	16	32 layers
Average ratio: R =	1.277	1.133	1.027	0.947

There is a consistent decrease of ratio with increasing thickness, from values considerably above 1 to values below 1.

Rate of voltage rise:	20 per cent	5 per cent	0.1 of 1 per cent per sec.
Average ratio: R =	1.231	1.079	0.987

There is a consistent decrease of ratio with decreasing rate of voltage application, down to values below unity.

The total average of all the values of the dielectric-strength ratio of cable paper is slightly above unity: R = 1.100. In other words, dry cable paper shows a slightly lesser dielectric strength for alternating than for direct voltage. Conversely stated, unimpregnated paper requires, on an average, a 10 per cent higher direct voltage than the peak alternating voltage, to puncture the same thickness of paper under otherwise identical conditions.

Since a laminated structure, consisting of a number of layers of unimpregnated cable paper, thus shows also a small deviation from the normal dielectric-strength ratio but opposite to that of either oil or petrolatum, it is of interest to consider the combination of both—that is, cable paper impregnated with the insulating hydrocarbon.

d. Cable Paper Impregnated with Petrolatum. If untreated cable paper (with a dielectric-strength ratio slightly above unity, viz: 1.100) is impregnated with petrolatum (which alone has a ratio slightly below unity—0.957) we might expect as a result of the combination of the two a ratio close to unity. On the contrary, the tests of impregnated paper show consistently very high ratios,—much higher indeed than dry paper,—and give an average ratio R = 1.773.

This result is very startling and its significance on insulation strength and failure is still far from being understood. The phenomenon of extra high ratio has, however, been checked and corroborated with data on several other materials of similar character.

Significant also is another factor—the enormous increase of dielectric strength, due simply to impregnation of the paper.

To get the general trend of the variation of the dielectric-strength ratio with the three controllable variables, namely temperature, thickness, and rate of voltage application, the tabulated data are again grouped for the purpose of comparison.

Temperature, Thickness, and Rate Data for Cable Paper Impregnated with Petrolatum.

Temperature:	25 deg.	50 deg.	75 deg.	100 deg.
Average ratio: R =	2.038	1.644	1.510	1.531

Thus the ratio consistently decreases with increasing temperature.

Thickness:	2	4 layers
Average ratio: R =	1.857	1.646

Thus the ratio decreases with increasing thickness

Rate of voltage rise:	20 per cent	5 per cent	0.1 of 1 per cent per sec.
Average ratio: R =	1.861	1.576	1.783

Thus the general trend is apparently that the ratio decreases with increasing slowness of voltage application, although the slowest rate shows a partial recovery.

This last group of data illustrates the difficulty of the investigation of the action of solid insulating material

and emphasizes the complexity and limited knowledge of the phenomena occurring in insulating materials under electric stress. The values averaged in the middle figure (1.576 at 5 per cent rate) were taken some weeks before the other two sets of tests, and while apparently the same materials were used and treated in the same manner and the general trend of variation is the same, a considerable difference occurs in the numerical values.

It is interesting to note that the ratio of direct voltage to peak alternating voltage of petrolatum-impregnated cable-paper, $R = 1.773$, in the comparison of direct voltage with the root-mean-square value results in the ratio—$\sqrt{2}\,(R = 1.773) = 2.501$. This value is the same as has been proposed as the results of extensive tests made abroad on cables.

B. Mica and Glass

Table II gives data on some inorganic insulation, such as mica and its compositions, and also glass. The table gives the name of the material, the data on sizes of electrodes, and either the gap length or number of layers; there are also the voltages of the tests using either direct or alternating voltage, and their ratio—that is to say, the dielectric-strength ratio of these materials. Here, as in the preceding table, each numerical value is the average of a number of tests—usually 10 or 25. For some of the materials, such as clear and pasted mica, glass, etc., the dielectric strength is given in kilovolts per mm. so as to compare the averages of the different tests made with slightly different thicknesses of material.

TABLE II
MICA, GLASS AND PARAFFIN

Material	Electrodes	Gap length cm.	No. of layers	Direct	Alternating	Dielec. str'gth ratio
				kv. per mm.		
Clear Mica, 0.12 to 0.18 mm. thick.....				100.5	98.0	1.025
Pasted Mica, 0.32 to 0.35 mm. thick.....				60.5 kv.	48.6 kv.	1.245
Mica Tape on Brass Tube..............			2	14.05	8.55	1.64
			4	34.9	21.9	1.59
			8	70.7	45.1	1.57
Mica Tape without sticking compound..			2	12.7	7.3	1.74
			4	21.5	12.7	1.69
			8	66.4	27.5	(2.42)
Mica Tape with sticking compound......			2	24.5	9.6	2.55
			4	48.1	20.2	2.38
	diam.			kv. per mm.		
Glass Tubing 0.7 to 0.85 mm. thick.....	2.54 cm.			68.0	46.3	1.469
				kv.	kv.	
Powdered Glass......	2.54 cm. spheres	1.90		37	44.5	0.832
		2.54		51.9	53.8	0.965
Powdered Glass made into paste with No. 6 transil oil..........	2.54 cm. spheres	0.63		56.8	61.6	0.922
		0.95		71.2	73.8	0.965
				kv. per mm		
Cast Paraffin 0.9 to 2.2 mm. thick......				17.4	16.8	1.036

The Dielectric-Strength Ratio of Mica in Several Forms. Clear mica gives a dielectric-strength ratio very little above unity, that is, in pure mica the dielectric strength is practically the same for alternating as for direct voltage. Possibly this low value of ratio indicates very low dielectric losses. Built-up or "pasted" mica however already shows a materially lesser strength for alternating than for direct voltage, a ratio of 1.245. Mica tape shows still much higher ratios, and mica tape put together with some organic sticker shows very high values. A comparison is made in the following averages:

Clear Mica................a ratio of 1.025
Pasted Mica...............“ “ “ 1.245
Mica Tape.................“ “ “ 1.646
Mica Tape held by a sticker.“ “ “ 2.46

Therefore the combination of two different materials in a laminated structure, here as in the preceding section A of impregnated paper, seems to raise the ratio. The ratio increases with the increase in the difference between the materials.

Apparently there is also a slight decrease of ratio with increasing thickness of the insulation, such as observed in the preceding studies.

The Dielectric-Strength-Ratio of Glass and Paraffin. Glass was tested, in the form of thin walled glass tubes, with mercury as inner electrode and tinfoil as outer electrode. Somewhat against expectation, glass, as the average of a number of tests, gave a high ratio — 1.469; that is to say, glass is dielectrically much stronger against direct than against alternating voltage. Whether or not this high ratio indicates a lack of homogeneity of the structure of the glass — as a colloidal solution — we cannot yet judge.

The glass of the tubes was powdered and the powdered glass in air was tested between 2.54 cm. spheres. Next, the powdered glass was mixed with No. 6 transil oil to form a paste, and this paste tested between 2.54 cm. spheres. Both the glass powder with the spaces between the particles filled with air, and that with the spaces filled with oil, show a dielectric-strength ratio slightly below unity (total average 0.921). That is, glass in solid form has a much greater dielectric strength for direct than for alternating voltage; as powder, however, its dielectric strength is less for direct than for alternating voltage. The explanation of this difference is still unknown.

In the same table have been added the averages of a number of tests made on thin cast disks of paraffin. They show a ratio close to unity, slightly above 1. — 1.036. This result seems reasonable.

C. Varnished Cambric and Paraffined Paper

Table III gives data on two kinds of insulating cloth — black and yellow varnished cambric, and cable paper

TABLE III

VARNISHED CAMBRIC AND PARAFFINED PAPER

Materials	Electrodes	No. of layers	Rate of voltage rise per cent per sec.	Direct voltage kv.				Alternating voltage kv.				Dielectric-strength-ratio			
				25 deg.	50 deg.	75 deg.	100 deg.	25 deg.	50 deg.	75 deg.	100 deg.	25 deg.	50 deg.	75 deg.	100 deg.
Black varnished cambric 0.3 mm. (asphaltum base)	5 cm. plates	1	5	21.8	18.1	16.0	14.5	17.4	15.9	15.6	14.7	1.253	1.138	1.026	1.014
		2	5	40.2				29.4				1.367			
Yellow varnished cam. 0.2 mm. (linseed oil base)		1	5	11.9	14.2	13.2	12.0	11.1	12.6	11.5	11.7	1.072	1.127	1.148	1.026
		2	5	19.3	23.8	21.0	19.2	17.3	22.4	22.2	19.4	1.116	1.062	1.054	0.990
		4	5	31.3	43.1	39.4	30.8	26.6	41.1	32.4	28.6	1.177	1.049	1.215	1.077
		1	5	19.4	20.1	14.0	9.5	14.4	15.0	9.2	10.2	1.347	1.340	1.525	0.932
		2	5	35.7	36.0	27.6	21.8	27.6	27.1	22.7	22.0	1.293	1.329	1.216	0.990
		4	5			43.5				42.2				1.031	
		1	2	21.2	18.0	11.5		14.4	13.9	9.8		1.472	1.295	1.173	
		2	2	38.8	31.7	22.5		24.2	23.5	22.4		1.600	1.350	1.005	
Cable Paper 0.2 mm. impregnated with paraffin		1	5	20.1				14.0				1.437			
		2	5	32.3				22.4				1.442			

impregnated with paraffin. Cable paper impregnated with paraffin gives in general the same characteristic as cable paper impregnated with petrolatum, as might be expected — that is, a high value of the ratio.

The data on both kinds of varnished cloth seem to show a decrease of dielectric strength with increasing temperature, and also a decrease of the dielectric-strength ratio with increasing temperature and possibly also with increasing thickness. Thus, grouping the average values as was done in previous cases, the results are as follows:

Temperature and Thickness Data for Yellow Varnished Cloth.

Temperature;	25 deg.	50 deg.	75 deg.	100 deg. cent.
Average Ratio: R =	1.297	1.222	1.171	1.003
Thickness:	1	2	3	layers
Average Ratio: R =	1.231	1.193	1.080	

The total average is R = 1.186.

The similarity of the change of the ratio in varnished cloth, with that in impregnated paper, raises the question whether it is not a general characteristic of compound laminated structures, to have a high dielectric-strength ratio at low temperatures, low thicknesses, and high rates of voltage rise, and conversely to have this ratio decrease with increasing temperature, increasing thickness and increasing slowness of voltage application.

MODEL TO ILLUSTRATE THEORY OF RELATIVITY

A device which directly conveys to the eye, the principal statements and results of Einstein's original (restricted) theory of relativity has recently been perfected by Prof. Karapetoff of Cornell University. Since, according to this theory, time is a concept not entirely different from that of space, the professor has replaced time by distances in his model. Certain parts are painted red to indicate the world as it appears to an observer, say A. Other parts are painted blue to characterize the same events as judged by another observer, say B, who is moving with respect to A. The event itself is painted in a third color, to indicate that it is common to both observers. The model not only illustrates the fundamentals of relativity, but also permits to check quantitatively the theoretical statements by actually measuring time intervals, distances, velocities, etc.

In particular the model makes it possible to visualize and to check the following: To a stationary observer a moving length seems shorter and a moving clock seems to run slow; velocities in the same direction are not added arithmetically, but according to a more complicated law; difficult optical phenomena, such as the reflection from a moving mirror and the so-called Doppler effect receive an elementary interpretation, and the numerical values can be measured directly.

Speaking of this device, Prof. Karapetoff said: "Similar representations of restricted relativity have been used before, but always using orthogonal coordinates for at least one observer. By using symmetrical oblique coordinates for both observers, I have been able to show a common event the way it appears to both, without calling one observer stationary and the other moving; this is then pure relativity. The same principle can be extended to the motion in a plane, and I am now designing a three-dimensional device to demonstrate phenomena which happen in a plane (like the aberration of light). I have also found a simple way of representing the magnetic and the electric intensities in a plane perpendicular to the direction of propagation of light, and their transmutation into each other for the observers A and B. This ought to make it possible to build still another model which will make a study of the propagation of electromagnetic disturbances in accordance with the theory of relativity much simpler."

The Standardization of Electrical Measuring Instruments[1]

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Review of the Subject.—*This paper points out the advantages, both to the maker and the customer, of national standard specifications for manufactured articles. The history of standardization in England is outlined. British specifications for electrical instruments appeared first in 1909, and in improved and enlarged form in 1919. French specifications were adopted in 1921, German in 1922.*

The outstanding features of the three foreign specifications are compared. The British go into much detail concerning scale construction and marking, the French concerning definitions and temperature rises. The German specifications contain very good definitions of instruments and their parts, principles, etc. They prescribe severe tests for mechanical and thermal robustness, and have an elaborate scheme of symbols to indicate the grade, operating principle, kind of current, test voltage, etc.

An account is then given of the consideration which the subject of instrument standardization has received in this country. The National Meter Committees have done a related piece of work by having the Meter Code prepared and revised, and have made recommendations to the makers from time to time concerning matters of instrument standardization. The Instruments and Measurements Committee of the Institute has considered the foreign specifications, and has determined by a personal canvass that a majority of American makers are in favor of standardization. However, this canvass also showed that most of them would have felt much freer to discuss proposed standard specifications rather than the abstract question as to whether specifications should be formulated. The Instruments and Measurements Committee therefore appointed a subcommittee of four members to prepare such tentative specifications, which are given as an Appendix to the paper. The specifications omit some important topics because the Subcommittee wished to include at the start only those on which general agreement could be had without difficulty.

The paper concludes with a discussion of some of the features of the tentative specifications.

Introduction

While the United States has led the world in applying the principles of interchangeability of parts and of quantity production to its manufacturing processes, it has only recently begun to appreciate the advantages of national standard specifications. The outbreak of war brought this question forward in very unmistakable fashion, and there is good reason to believe thatat no distant time the advantages of "national uniformity of buying and selling requirements" will be as much appreciated here as abroad.

The purposes to be served by such specifications may be regarded from two standpoints. The manufacturer is benefited because he can devote his energies to certain definite lines for which the demand can be confidently anticipated. With the limitation of his output largely to standard grades, ranges, and finishes, unit-costs are decreased, demands can be more closely estimated, raw materials can be bought in fewer kinds and sizes and in larger quantities, and overhead costs are reduced. If the national specifications under which the maker works have attained a good standing abroad, a further important advantage is secured, in that surplus stocks are immediately available for export instead of goods made up specially with the attendant increased cost.

From the purchaser's viewpoint, standard specifications are useful in selecting the most suitable apparatus for given requirements, and in obviating the necessity for individual study and the preparation of independent specifications. It is only when the articles bid on have been made under the same requirements as to quality and performance that an intelligent selection can be made from a number of bids. As an illustration of the condition that is produced by lack of standard requirements, we may cite current transformers. As now made, these are classified by each manufacturer in such general terms that a purchaser can readily pick out the extreme grades, especially with the relative prices as a guide. But it is not possible for him to choose the best transformer from the offers of several manufacturers, for the rating "50 volt-amperes, compensated for 25 volt-amperes," for example, does not throw much light on the matter, in the absence of uniform practise as to permissible ratio and phase-angle errors. The purchaser is compelled to fall back on his impressions of the relative standing of the manufacturers concerned.

Both manufacturer and purchaser lose in the absence of national specifications, on account of which different individual specifications necessarily arise. The diversity of requirements that may thus arise increases engineering and manufacturing costs and hence the cost to the purchaser. A case in point is that of Government specifications. The Navy Department, which very properly buys its supplies on definite specifications, is compelled to go to the expense of preparing complete specifications for electrical instruments, both for power-plant use and for radio purposes. If American standard specifications were in existence, the Navy Department could use them, with only a few added clauses to take care of the special requirements which exist only in naval work.

Instrument Standardization Abroad

The work of national standardization in Great Britain began in 1901 when the Council of the Institu-

1. Published by permission of the Director of the Bureau of Standards.

Presented at the Annual Convention of the A. I. E. E., Swampscott, Mass., June 26-29, 1923.

tion of Civil Engineers appointed a committee to consider the advisability of standardizing various kinds of iron and steel sections. The cooperation of three other British societies (Mechanical Engineers, Iron and Steel Institute, Naval Architects) was at once secured, and the work of preparing specifications was begun. A year after the formation of the "Engineering Standards Committee" it was suggested that the subject of electrical machinery and apparatus be included in its scope, and with the cooperation of the Institution of Electrical Engineers this work was begun. That the results of the labors of the Standards Committee have been appreciated is shown by its growth from a single committee of seven members to a great organization, the British Engineering Standards Association, consisting of a Main Committee of 24 members. The Report of the Association dated July 1, 1919, showed that 26 sectional committees appointed by the main committee were functioning, and that they had appointed 78 subcommittees and 144 "panel committees," making a total of 249 committees with an aggregate membership of over 1100. Another indication of the importance of the work is found in the range of subjects for which specifications have been prepared or are under way. As given in reports of January 1, 1923 these included:

Civil Engineering and Building Trade	25
Mechanical	36
Electrical	76
Automotive (Aircraft and Automobile)	164
Transport	16
Ships and Their Machinery	42
Ferrous Metals	10
Non-Ferrous Metals	46
Chemical, Including Chemical Engineering	14
General	4

The first British Standard Specification for electrical instruments was No. 49 on ammeters and voltmeters, adopted in 1909, as the result of nearly two years of work by a subcommittee. Shunts, resistors, and instrument transformers were not included in this specification.

In 1919 this specification was superseded by No. 89 on indicating ammeters, voltmeters, wattmeters, frequency and power factor meters. At the same time two other related specifications were issued; No. 81 on instrument transformers and No. 90 on recording (graphic) ammeters, voltmeters, and wattmeters. Specification No. 89 was a very distinct advance over its forerunner, No. 49.

French standard specifications for electrical measuring instruments, instrument transformers, and shunts were prepared by a Technical Committee[2] with the collaboration of representatives of the makers, the Laboratoire Centrale d'Électricité, and a consulting engineer (Mr. A. Iliovici) specializing in electrical instruments. These specifications[3] were adopted by the Chambre on January 20, 1921.

German specifications for electrical instruments were prepared by a committee of the Verband Deutscher Elektrotechniker. A proposed draft was published[4] in March, 1921, and was intended to become effective on July 1, 1922. This draft evoked criticisms and suggestions which were used in preparing a considerably revised one, which appeared[5] a year later. This revised draft was adopted by the Verband at its 1922 meeting, and is to go into effect on July 1, 1923.

German specifications for instrument transformers[6] were prepared by the Verband, and went into effect on July 1, 1922.

It is of interest to compare the outstanding features of these three national specifications. In general, the British specifications are probably the most satisfactory from the American viewpoint, though they leave some important points untouched. They treat with considerable detail the important question of scale construction and marking. Three classes as regards accuracy are provided, called Sub-standard, First Grade, and Second Grade respectively. Insulation and dielectric strength are carefully specified. Limits of error are given for the three grades, and limiting values of influences of operating conditions (temperature changes, frequency changes, external magnetic fields, etc.).

The French specifications open with an elaborate set of definitions, which in the main are very good. Instruments are classified first into two groups, Laboratory and Industrial, the former including special or delicate devices used either to measure very small magnitudes or to measure ordinary magnitudes with high precision.[7] The second broad classification is denoted Industrial Instruments, and is further divided into Standard Instruments, Control[8] Instruments, Switchboard Instruments, and Ordinary Instruments, of which latter all that is said is "This group includes all measuring instruments of which the essential quality is a low price." Requirements stated for the other classes include accuracy, damping, mechanical robustness, heating, and dielectric strength. The French specifications are the only ones which give a list of recom-

2. Of the "Chambre Syndicale des Constructeurs de gros Matériel Électrique."

3. They were published in *Revue Générale de l'Électricité*, vol. 9, pp. 119c-134c, May 28, 1921.

4. *Elektrotechnische Zeitschrift*, vol. 42, p. 324, March 31, 1921.

5. *Elektrotechnische Zeitschrift*, vol. 43, p. 290, March 2, 1922. Some minor corrections and changes were published in the same journal, vol. 43, p. 1074, August 17, 1922.

6. *Elektrotechnische Zeitschrift*, vol. 42, pp. 209, 836; Mar. 3, July 28, 1921.

7. Actually, the French specifications do not cover these special laboratory devices, nor do either of the other national specifications.

8. This is a literal translation; "working-standard" is perhaps a better rendering.

mended ampere ranges[9] for the current coils of instruments.

The French specifications go into great detail in regard to the permissible temperature rises of conducting materials and various kinds of insulating materials in instruments.

The German specifications divide instruments as follows:

Precision Instruments,	first class	
"	"	second "
Operating	"	first "
"	"	second "

They contain a very good set of definitions of instruments and their parts, operating principles, ranges, kinds of cases, etc. They introduce a concept not found in either of the other specifications, namely, "minimum creeping distance," which is defined as the shortest path along which current can flow over the surface of an insulator between metal parts which have a difference of potential between them.

In addition to prescribing limits of accuracy and for the effects of temperature change, etc., the German specifications are unique in specifying a maximum distance of the pointer from the scale, and in requiring switchboard voltmeters and ammeters to be capable of carrying continuously a voltage or current 20 per cent greater than full-scale value. When it is considered that this overload means a heat loss in the instrument 44 per cent more than that caused by rated voltage or current; that voltmeters are ordinarily installed to work on about three-fourths of full-scale value; and that even full-scale value on a switchboard ammeter usually corresponds to an overload condition of the associated apparatus, it seems that the German requirement will involve some economic waste of materials in the construction of instruments.

In addition to the stipulated accuracies of precision instruments, the German specifications permit additional errors in the following cases:

For instruments having voltage circuits exceeding 250 volts, 0.1 per cent additional;

For instruments with interchangeable series resistors, 0.1 per cent additional;

For instruments with interchangeable shunts, 0.2 per cent additional.

Another outstanding feature of the German specifications is the extent to which they carry the use of symbols to serve as concise statements of certain features. In addition to the letters E, F, G, H denoting the four classes above mentioned, symbols are provided for the following kinds of current: d-c., a-c.; two-phase, balanced three-phase, unbalanced three-phase, and four-wire three-phase. Position symbols show that instruments are for use in horizontal, vertical, or oblique position. Another set of symbols denotes the kind of mechanism (moving-iron, induction, etc.). This is a desirable feature in instruments for general laboratory work, because it assists the user to select the most suitable instruments for such cases as unusual frequencies, for example. The use of a black, brown, red, blue, or green star denotes that the instrument is for a particular operating voltage, the black denoting "not over 40 volts," and the green "901 to 1500 volts."

The French and German specifications impose tests for robustness, while the British specifications ignore this important point. The French requirement of "twice the current corresponding to full-scale deflection, applied suddenly and for a very short time" is virtually a mild test of *mechanical* robustness only, because the thermal inertia of current windings would make the resulting rise of temperature very small. The German requirement is much more severe, and may properly be called a test of mechanical and thermal robustness. It specifies that the test current shall be 10 times that corresponding to the maximum value of the range of measurement, and that it shall be applied as follows:

9 impulses of 0.5 second in intervals of 1 minute each, then

1 impulse of 5 seconds duration.

With this current, which generates heat in the windings at 100 times the normal rate, the instrument receives a severe mechanical test and a searching test for any thermally weak spots.

The question of damping is variously handled. The British specifications require the pointer to settle to a definite indication "in a reasonable time," and in an appendix the "extreme limits of reasonable time" are given as follows:

Scale length in inches Not over	Time in seconds
4.5	2.5
7	3
12	5

The German requirement is more logical in that it bases the time to come to rest on the length of the pointer, and on the class of instrument, as follows:

Precision instruments,	both classes,	$3 + L/100$	seconds,
Operating "	first class,	$3 + L/50$	"
" "	second "	$4 + L/50$	"

where L is the length of the pointer, measured in millimeters.

The French specifications characterize damping by two quantities:

1. The ratio of the first swing to the steady deflection when the appropriate current is suddenly passed through the instrument.

2. The time required for the pointer to come to rest, under the same conditions.

Incidentally, for practical purposes the pointer is assumed to come to rest when it is within 1 per cent of the steady deflection.

9. The same values are also recommended as the primary ranges of current transformers. For voltage transformers a list of recommended transformation ratios is given.

The British specifications require zero adjusters on (spring-controlled) sub-standard and first-grade instruments. The German specifications require them for precision apparatus of both grades, and the French make no mention of the matter.

Consideration in the U. S.

The Meter Committee of the Association of Edison Illuminating Companies has used its influence to encourage the standardization of watt-hour meters. With the corresponding Committee of the National Electric Light Association, it inaugurated the preparation by Electrical Testing Laboratories of the Meter Code, which has been of great service to the meter industry.

Since the checking of watt-hour meters involves the use of indicating instruments, it is only natural that the national Meter Committees should at times make recommendations concerning them. Among these the following work of the N. E. L. A. Meter Committee and Apparatus Committee may be noted:

Proposed Standardization System of Connections for Instruments and Meters used with Current and Voltage Transformers, 1913 and 1914 Reports.

Standardization of Shunts for Instruments and Meters, 1914 and 1915 Reports.

Standardization of Design and Maintenance Method for Instrument Transformers, 1916, 1917, and 1918 Reports.

Standardization of Meter and Instrument Design, 1921 and 1922 Reports.

Standardization of Instrument Transformers, 1922 Report.

The Instruments and Measurements Committee of the Institute has a keen interest in all questions relating to instrument standardization. At the request of this committee, the writer presented a paper[10] three years ago, in which the British Specifications were mentioned, with a table of required accuracies for various kinds and classes of instruments. A little later this committee took up the question of instrument terminology. A list of words relating to instruments, their operating principles, parts, functions, etc., was drawn up, and the various divergencies and inconsistencies were discussed with the hope of establishing a list of recommended terms which might eventually supersede the imperfect terminology in use. While some useful points were brought out in the discussion, the committee felt that the standardization of the terminology of instruments was a part of a larger job and the matter was therefore held in abeyance.

In 1921 the proposed German specifications for instruments and for instrument transformers were published. In order to get these specifications in convenient form for discussion, they were translated into English. Copies of the translation were sent to the members of the Instruments and Measurements Committee and the Meter Committees of the N. E. L. A. and the Edison Association. The Instruments and Measurements Committee appointed the writer as a subcommittee of one to canvass the sentiment of the instrument manufacturers of this country as to the necessity or desirability of American standard specifications covering their products.

Before this canvass was begun, the French specifications were translated, and copies were sent to the above-named committees. Copies of the French, German, and British specifications were sent out early in 1922 to the American manufacturers of electrical instruments and accessories, and soon after the personal canvass was begun. In all, twenty-one concerns were visited. Some of them make a complete line of instruments and accessories, while others make accessories (for example, instrument transformers) as adjuncts to other lines, such as watt-hour meters.

The results of the canvass showed that a majority of the makers were in favor of standard specifications, though some questioned the necessity or advisability of their preparation at the time. Two important ideas, however, came to the surface. The first was that many of the manufacturers would have felt much freer to express opinions if proposed American standard specifications had been placed before them, instead of only the abstract question as to the desirability of formulating such specifications. The second was that it would be entirely proper for the A. I. E. E. Instruments and Measurements Committee to prepare such specifications to serve as a basis for criticisms and suggestions.

Following out this suggestion, Chairman Sawin of the Instruments and Measurements Committee appointed a subcommittee for this purpose. The membership of this subcommittee included Mr. F. P. Cox of the General Electric Co., Mr. G. L. Crosby of the Roller-Smith Co., Mr. P. MacGahan of the Westinghouse Electric & Mfg. Co., and the writer, as chairman. The three foreign specifications were carefully considered, and what appeared to be the best features of each were woven into a preliminary draft. This was carefully revised by the subcommittee. The final draft, as here given, was prepared in a joint session of the subcommittee and the Instruments and Measurements Committee.

The Instruments and Measurements Committee authorized the writer to prepare a paper presenting the tentative specifications, in order to get them before the entire membership of the Institute. They are given as an Appendix herewith. All makers and users of electrical instruments are earnestly invited to send written comments, and criticisms of the scope and subject matter of the specifications to the writer, care Bureau of Standards, Washington, D. C., for the guidance of the subcommittee in the further development of these tentative specifications.

10. The Accuracy of Commercial Electrical Measurements, Jour. A. I. E. E., vol. 39, p. 495, 1920.

It will be noted that a number of important topics are not covered in these specifications, though they are carefully treated in the foreign ones. This is not because the subcommittee considers these topics unimportant, but rather because it is felt best to begin with things about which general agreement can easily be reached. On the matter of accuracy of calibration, for example, considerable difference of opinion exists. Probably no customer would care to buy instruments concerning which absolutely no statements or guarantees of accuracy are given by the maker. However, since undue importance is sometimes attached to high accuracy, and because the accuracy of instruments in service is so largely under the user's control, it was felt that for the present the specifications should leave it to the maker and customer to agree on the accuracy required in each case. The same statement applies to the permissible limits for the various influences of operating conditions.

Some specific comments on other features of the appended specifications will now be given.

I-2. *Kinds of Instruments Included.* Under this heading the German specifications limit current and voltage capacities to 1000 amperes and 20,000 volts, because "With larger values of current and voltage it is difficult to keep within the prescribed limits of accuracy, and the checking of the accuracy becomes difficult."

III-1. In defining the words "instrument" and "indicator" the subcommittee followed the example of the British specifications, but with an important difference in the definition of "indicator". There is no question as to the need for the distinction between instrument and indicator, and the only argument against taking this step was that early in the history of electric lighting in this country the word "indicator" was sometimes[11] used to denote a device of low accuracy. It was finally agreed that this usage was now practically obsolete, and was therefore no bar to the use of the word "indicator" in its new sense.

Attention is invited to the distinction between the terms "series resistor" and "multiplier". These terms should not be confused.

III-4. *Damping.* For the present this term is simply defined. Section 8302 of the Standards of the Institute prescribes the method by which damping shall be measured. Three quantities are to be observed, as follows: The number of swings made by the pointer in coming to rest; the time (in seconds) required for the pointer to come to rest; the overshooting, in per cent of the angular displacement due to the initial disturbance.

III-5, 6. *Torque and Weight.* For the present these sections are limited to simple definitions of these quantities and a statement of the units employed. In view of the extensive mention of the ratio of torque to weight as a criterion of the degree of excellence of an instrument as regards frictional error, it should be stated that this time-honored criterion is now known to be incorrect save when the moving elements of the instruments to be compared have equal weights. (Equality of excellence of pivots and jewels is assumed). The use of the simple ratio of torque to weight is based on the incorrect assumption that the area of pivot in contact with the jewel is independent of the weight, whereas it must necessarily increase with the weight. By the simple rule of torque to weight, certain small American instruments having very light coils would be expected to stick so badly as to be useless, whereas actually they work very well. If we use the expression, torque divided by weight to the nth power, and take for n a value greater than unity and less than 2, more concordant results will be obtained. A prominent German specialist[12] in electrical measuring instruments gives as a satisfactory criterion, based on practical experience, the quotient, torque divided by the 1.5-power of the weight.

IV-1. It is not felt opportune to make a subdivision of instruments as to "class" or "grade". A suggested classification, which it was not thought advisable to adopt at this time, was as follows:

1. As to use:

(a)	Portable Instruments,	Precision Grade	
(b)	" "	Utility	"
(c)	Switchboard "	High	"
(d)	" "	Industrial	"

It was also suggested that "laboratory-standard" instruments form a third class (in addition to portable and switchboard).

IV-2c. The adjective "electrodynamic" is advanced for consideration as a logical substitute for the lengthy term "electrodynamometer-type" and the abbreviated (and not strictly correct) term "dynamometer"[13]. The French, Germans and Italians use the forms corresponding to "electrodynamic" (électrodynamique, elektrodynamisch, elettrodinamico).

It should be emphasized that in drawing up these specifications the effort has been made to maintain a harmony of treatment and of substance with the Standards of the A. I. E. E. It should also be noted that the present specifications are not put forward as a finished product. In their present form, however, it is felt that they will be valuable for their intended use as a tangible basis for discussion and as a nucleus about which finished specifications may in due time be realized. Such specifications should be prepared with the approval of the Institute, and in accordance with the

11. This was not the general practise, however, for the device by which early Edison stations measured the voltage at feeder-ends was known as the Howell indicator.

12. Dr. G. Keinath, of the Siemens & Halske A. G. of Berlin. See his book "Die Technik der elektrischen Messgeräte," second edition, pages 20-22.

13. The term "dynamometer" means "that which measures force." A spring balance is a dynamometer, and some forms of spring balance are called dynamometers.

procedure of the American Engineering Standards Committee.

Appendix

Proposed American Specifications for Electrical Measuring Instruments

Outline

I. *Introduction*
  1. Origin and Purpose
  2. Kinds of Instruments Included

II. *Standards*
  1. General
  2. Units; Legal Standards
  3. Reference Temperature
  4. Standard Ambient Temperature

III. *Fundamental Definitions*
  1. Instruments and Their Parts
  2. Rating
  3. Scales
  4. Damping
  5. Torque
  6. Weight
  7. Error and Correction
  8. Influences of Operating Conditions
     (a) Temperature Influence
     (b) Frequency "
     (c) Voltage "
     (d) External-Field "
     (e) Power-Factor "
     (f) Position "

IV. *Classification*
  1. As to Use:
     (a) Portable Instruments
     (b) Switchboard "
  2. As to Principle of Operation
     (a) Dynamometer (Electrodynamic)
     (b) Permanent-Magnet Moving-Coil
     (c) Moving-Iron
     (d) Induction
     (e) Electrothermic
     (f) Electrostatic
  3. As to Kind of Protection by the Case:
     (a) Dust-Proof
     (b) Moisture-Proof
     (c) Rust-Resisting
     (d) Water-Tight (submersible)

V. *Requirements*
  1. Construction
  2. Rating
  3. Insulation Resistance and Dielectric Strength
  4. Scale and Pointer
  5. External Shunts
  6. Marking

I. Introduction

1. *Origin and Purpose.* These specifications were prepared for the Instruments and Measurements Committee of the American Institute of Electrical Engineers by a subcommittee appointed for the purpose. In their present form they are intended to serve as a tangible basis for discussion on the part of makers, users, and laboratory men engaged in testing electrical measuring instruments, in order to determine whether American standard specifications of this general nature would be of advantage to all concerned, and if so, what changes in and additions to these specifications are required to make them suitable for the purpose.

The objects of these specifications are as follows:

1. To standardize the principal terms used in describing instruments and their parts, functions, operating principles, etc.

2. To promote a more complete understanding between the maker and the user concerning the essential characteristics of instruments for definite applications.

3. To eliminate diversity of purchase specifications for instruments for similar uses.

The limitations of the specifications may be stated as follows:

1. They are of necessity limited to certain broad classes of electrical instruments, and there will always be special devices not falling entirely within their scope. In many cases, however, the specifications may be used together with certain additions to cover the special features.

2. They are subject to revision from time to time as the art of instrument making advances, or as the requirements of practise change. They are not intended to restrict development or prevent improvement, but rather to guide progress along the most efficient lines.

3. They are not intended to cover the necessary legal provisions of a contract, but only the technical requirements of a purchaser in ordering or a maker in bidding.

2. *Kinds of Instruments Included.* These specifications apply for the present to the following kinds of indicating electrical instruments for direct current and for alternating current:

Ammeters,
Voltmeters,
Wattmeters,
Frequency Meters,
Power-Factor and Phase Meters,
Reactive-Factor Meters.

These specifications are not intended to apply to indicating instruments provided with arrangements for curve drawing, contact making, etc. They do not apply to the following kinds of instruments:

(a) Small instruments of types and sizes which are used where the requirements are not severe, and where low cost is essential; for example, small polarized-vane ammeters used on automobiles, battery-charging outfits, etc.

(b) Instruments constructed for very special requirements.

II. Standards

1. *General.* Electrical measuring instruments shall conform to such general requirements of the Standards of the American Institute of Electrical Engineers as shall be applicable to instruments, when such requirements are not definitely covered in the following specifications.

2. *Units, Legal Standards.* The accuracies specified by maker and purchaser are to be based on the legalized international electrical units.

3. *Reference Temperature.* The standard temperature of reference for instrument characteristics shall be 20 deg. cent.

4. *Standard Ambient Temperature.* For purposes of rating instruments, the standard ambient temperature shall be 40 deg. cent. See definition of rating, p. 7

III. Fundamental Definitions

1. *Instruments and their Parts.* An *instrument* is a measuring device which indicates the present value of the quantity under observation. The term "instrument" includes the indicator (as defined below) together with any accessory apparatus such as shunts, shunt leads, resistors, reactors, condensers, or instrument transformers.[14]

The *mechanism* is the arrangement for producing and controlling the motion of the pointer. It includes all the essential parts necessary to produce this result, but does not include the base, cover, scale, or any parts, such as series resistors or shunts, whose function is to make the readings agree with the scale markings.

The *moving element* includes the pointer and the parts which move with it.

The *indicator* is the mechanism and the scale, built into the case, including any accessory devices (resistors, shunts, etc.) which are built into the case or non-removably attached to it.

Examples: An instrument (ammeter) for 500 amperes direct current consists of the indicator (which may be thought of as essentially a millivoltmeter) together with a 500-ampere shunt and a pair of shunt leads. Another instrument (wattmeter) consists of the indicator (which is essentially a 5-ampere 110-volt wattmeter) together with a current transformer and a potential (voltage) transformer.

An instrument is said to be *self-contained* when all accessory apparatus necessary to cause the scale reading to correspond with the numerical value of the quantity measured is enclosed within or permanently attached to the indicator case.

The *current circuit of an indicator* is that winding (or other conducting path) of the indicator which carries the current to be measured, or a definite fraction of it, or a current dependent upon it.

The *voltage circuit of an indicator* is that winding of the indicator to which is applied the voltage to be measured, or a definite fraction of it, or a voltage dependent upon it.

The *current circuit of an instrument* is that winding (or other conducting path) of the instrument which carries the entire current to be measured.

The *voltage circuit of an instrument* is that winding of the instrument to which the entire voltage to be measured is applied.

Example: An a-c. wattmeter for 1000 amperes, 6600 volts, consists of an indicator (which is essentially a 5-ampere, 110-volt wattmeter with its scale marked to read primary power) together with a current transformer of 1000: 5 amperes and a potential (voltage) transformer of 6600:110 volts. The current circuit of the indicator is its 5-ampere winding, and its voltage circuit is its 110-volt winding. The current circuit of the instrument is the 1000-ampere winding of the current transformer, and the voltage circuit of the instrument is the 6600-volt winding of the potential (voltage) transformer.

A *series resistor* is a resistor forming part of the voltage circuit of an indicator or an instrument.

A *multiplier* is a particular type of series resistor which is used to extend the voltage range of an instrument beyond some particular value for which the instrument is already complete.

A *shunt* is a resistor connected in the circuit to be measured and in parallel with the current circuit of an indicator.

A *reactor* is a device used for the purpose of introducing reactance, and usually has a high time-constant.

Shunt leads are leads which connect the current circuit of an indicator to the shunt.

2. *Rating.* The *rating of an instrument* is a designation assigned by the manufacturer to indicate its operating limitations. The full-scale marking of an instrument does not necessarily correspond to its rating.

3. *Scales.* The *indication range* is the range within which the electrical quantity (current, voltage, power, etc.) is to be indicated without reference to accuracy.

The *measurement range* is that part of the range of indication within which the requirements for accuracy are to be complied with.

The *scale length* is the length of the arc described by the end of the pointer in moving from the zero position to the end of the scale.

4. *Damping.* This is a term applied to instrument performance to denote the manner and the rapidity with which the pointer settles to its steady reading after a change in the value of the measurement quantity.

5. *Torque.* The *torque* of an instrument is defined as the turning moment which is developed by its mechanism when holding the pointer in the position of full-scale deflection. Torque is to be expressed in millimeter-grams, and should be accompanied by a statement of the angle corresponding to full-scale deflection.

14. It is proposed to cover instrument transformers by separate specifications.

6. *Weight.* The *weight* of a moving system includes one-half the weight of the springs, if any. It is to be expressed in grams.

7. *Error and Correction.* The error of indication is the difference between the indication and the true value of the quantity being measured. It is the quantity which must be algebraically subtracted from the indication to get the true value. A positive error denotes that the indication of the instrument is greater than the true value.

The correction has the same numerical value as the error of indication, but the opposite sign. It is the quantity which must be algebraically added to the indication to get the true value. If T, I, E and C represent respectively the true value, the indicated value, the error, and the correction, the following equations hold:

$$E = I - T$$
$$C = T - I$$

Example: A voltmeter reads 112 volts when the voltage applied to its terminals is actually 110 volts. Then

Error = 112 − 110 = +2 volts
Correction = 110 − 112 = −2 volts.

8. *Influences of Operating Conditions.* (a) The *temperature influence* is defined as the percentage change in the indication which is caused solely by a difference in room temperature of ± 10 deg. cent. from the reference temperature (20 deg. cent.)

(b) The *frequency influence* (in other than frequency meters) is defined as the greatest percentage change in the indication which is caused solely by a change of ± 10 per cent from the rated frequency.

(c) The *voltage influence* (in other than voltmeters) is defined as the greatest percentage change in the indication which is caused solely by a change of ± 10 per cent from the rated voltage.

(d) The *external-field influence* is defined as the percentage change in the indication which is caused solely by an external field of an intensity of 5 gausses produced by a current of the same kind and frequency as that on which the instrument operates, with the most unfavorable phase and position of the external field.

(e) The *power-factor influence* (in wattmeters) is defined as the percentage change of the indication which is caused solely by the lowering of the power factor from unity to 0.50, current lagging, at the rated voltage and frequency.

(f) The *position influence*, in other than gravity-controlled instruments, is defined as the maximum displacement of the pointer which is caused solely by an inclination of 30 deg. in any direction from the normal position of use. It is to be expressed as a percentage of the scale length.

IV. Classification

Electrical instruments may be classified as follows:

1. *As to Use:*
   - (a) Portable instruments
   - (b) Switchboard "
2. *As to Principle of Operation:*
   - A. *Electromagnetic*
     - (a) Dynamometer (Electrodynamic)
     - (b) Permanent-Magnet Moving-Coil
     - (c) Moving-Iron
       - (1) Plunger
       - (2) Vane
       - (3) Repulsion
     - (d) Induction
   - B. Electrothermic
     - (a) Expansion
     - (b) Thermocouple
   - C. Electrostatic

Note: Instead of "permanent-magnet moving-coil" the following terms were also suggested: "d'Arsonval;" "fixed-field." Instead of the principal heading A, "Electromagnetic," the term "electrodynamic" was also suggested.

3. *As to Kind of Protection:*
   - (a) Dust-Proof
   - (b) Moisture-Proof
   - (c) Rust-Resisting
   - (d) Water-Tight (Submersible)

The terms "portable" and "switchboard" are self-defining. A third classification as to use is suggested, namely, "laboratory-standard."

In *dynamometer (electrodynamic) instruments* one or more coils move within the field produced by a fixed coil or coils.

In permanent-magnet moving-coil instruments a coil moves within the field of a permanent magnet.

In *moving-iron instruments* one or several pieces of soft iron are caused to move by the magnetic field of a fixed coil or coil system. Various forms of this instrument (plunger, vane, repulsion) are distinguished chiefly by mechanical features of construction.

In *induction instruments* the torque is produced by fixed coils acting upon moving conducting parts (disks, drums, etc.) in which currents are produced by electromagnetic induction.

Electrothermic instruments depend for their operation on the heating effect of a current. Two distinct types are (1) the expansion type, including the "hot-wire" and "hot-strip" instruments; (2) the thermocouple type, where one or more thermocouples which are heated directly or indirectly by the passage of a current supply a direct current which flows through the coil of a suitable direct-current mechanism, such as one of the permanent-magnet moving-coil type.

Electrostatic instruments depend for their operation on the forces of attraction and repulsion between bodies charged with electricity.

A *dust-proof instrument* is provided with a case which excludes dust from the mechanism.

A *moisture-proof instrument* is one in which moisture is excluded from the mechanism, or which is so constructed that moisture will not damage the mechanism.

A *rust-resisting instrument* is one whose case and parts are made of rust-resisting materials, or are specially finished to resist the corrosive effects of moist air.

A *water-tight* (*submersible*) *case* withstands for one hour complete immersion in a tank containing sufficient water to cover all parts to a depth of at least three feet, without any visible trace of penetration of water into the interior.

V. Requirements

1. *Construction.* The construction of electrical instruments shall be mechanically sound, suitable to their class and purpose, and shall be such as to give assurance of permanence in the accuracy of the indications. All materials must be suitable for the purpose for which they are used.

2. *Rating.* The rating of the circuits of an instrument shall be equal to, or less than, the maximum current or voltage to which they may be continuously subjected without exceeding the permissible temperature rises. These rises are to be those specified for the various classes of insulating materials by the Standards of the A. I. E. E., and refer to the standard ambient temperature of 40 deg. cent.

If the rating of an instrument differs from the full-scale marking, the rating shall be marked on the instrument.

The limiting observable temperature of shunts shall not exceed 120 deg. cent. It shall be measured by mercury, alcohol, or resistance thermometers or by thermocouples, any one of these devices being applied to the hottest accessible part of the shunt. *Exception.* This rule shall not apply to shunts having no soldered joint and made of material which is not permanently changed in resistivity if continuously subjected to a higher temperature.

3. *Insulation Resistance and Dielectric Strength.* Tests for insulation resistance and dielectric strength shall be made on finished instruments.

The *insulation resistance* between all the electrical circuits of an indicator connected together and the case shall not be less than 20 megohms, as measured with a d.c. test voltage of 500 volts. The insulation resistance between the current circuit and the voltage circuit of an indicator (where both exist) shall not be less than 5 megohms.

When indicators are specified to have one or more of the circuits internally connected to the case, the necessary exceptions to these requirements are allowed.

Dielectric strength tests shall be made with a wave form which is nearly sinusoidal and of a frequency between the limits of 15 and 65 cycles. Tests shall be made between all the electrical circuits of the device connected together and the case. *Instruments having a voltage circuit* shall withstand for 60 seconds a test of twice rated voltage plus 1000 volts. *Instruments without a voltage circuit* shall withstand for 60 seconds a test of 1000 volts. These are effective (root-mean-square) values.

4. *Scale and Pointer.* The *preferred value of each scale division* should be either 1, 2, or 5 of the units measured, or any decimal multiple or submultiple of these numbers. In the case of multiple-range instruments exceptions to this rule may be necessary, but should be avoided where reasonably possible.

The *angle subtended by a scale division* shall preferably not be less than 0.5 degree in portable instruments, or 1 degree in switchboard instruments. When smaller angles are used, the legibility is decreased.

The *numbers marked on the scale*, except in the lower part of non-uniform scales, shall preferably be by steps of 1, 2, or 5, or a decimal multiple or submultiple of any of these numbers. The figures shall be of such shape as to minimize the risk of different figures being confused with one another, and shall be so spaced as to render individual numbers clearly distinguishable from adjacent numbers.

In determining the influences of operating conditions (a) to (e) inclusive, page 8, ammeters and voltmeters should be tested with rated current or voltage respectively. Wattmeters should be tested with rated voltage and such a current (not exceeding the rated current) as will give a suitable deflection, preferably not less than that corresponding to one-half of the maximum reading. Frequency meters (except in the test for voltage influence) should be tested at rated voltage. Power-factor meters and reactive-factor meters should be tested with rated voltage and rated current, unity power factor.

5. *External Shunts.* The *main terminals* of the shunt shall be so constructed that slight variations in the manner of connecting it in the circuit (such as might occur in an average workman-like installation) shall not alter the indication of the instrument by more than 0.25 per cent.

The *thermal electromotive force* produced by continuous operation of the shunt at rated current shall not exceed the value which would cause a change in the reading (at rated current) of 0.25 per cent. The connections to the circuit should be made so that the opportunity for the escape of heat will be the same at both terminals.

6. *Marking.* The *indicator* shall be distinctly marked with the following particulars in such a way that they will be visible from the front of the case: Name (or symbol) of manufacturer; serial number; designation of the quantity measured; the words "direct-current" or "alternating-current" or their abbreviations; the rated current, voltage or frequency (or the ranges of these quantities) or such of these as apply; the maximum

current and voltage, in the case of wattmeters, power-factor meters, and reactive-factor meters. Of these, only the scale marking itself and the designation of the quantity measured shall be conspicuous.

In the case of alternating-current instruments the following additional items are required: Ratio of the appropriate current transformer expressed thus: 1200:5 or 1200/5; ratio of the appropriate potential (voltage) transformer expressed thus: 6600:110 or 6600/110.

The indicator of an ammeter having separate shunts shall also be marked with the drop of the shunt with which it is to be used, corresponding to full-scale deflection.

Instruments having separate shunts or series resistors should be marked to indicate this fact.

Separate shunts, if not interchangeable, shall be marked as follows: Name (or symbol) of manufacturer; serial number of the indicator with which it was calibrated; the line current corresponding to full-scale deflection of the indicator; the rated current, if this is less than the preceding, and the drop at rated current. When the shunts are designed to be used with devices taking sufficient current to be an appreciable proportion of the whole, this fact shall be indicated.

Interchangeable separate shunts shall bear the above markings, except that the serial number may be omitted.

HYDROELECTRIC DEVELOPMENT IN SOUTHERN ITALY

Financing of the Societa per le Forze Idrauliche della Sila and other hydroelectric companies in southern Italy, recently arranged by the help of the Government with the Bank of Naples, Bank of Sicily, and others, will provide funds to carry on the work of the important water-power projects in the Sila Mountains in Calabria. This is one of the most ambitious projects undertaken in Italy in recent years.

As early as 1906 engineers made preliminary studies of the hydroelectric possibilities in this district and the present company was formed in 1908. Unfavorable laws regarding water power and lack of funds held up the work. Finally, in 1913, a new law was passed which established more liberal terms in the handling of water-power concessions, and in 1916, during the war, a formal license was given the Societa per le Forze Idrauliche della Sila.

Construction work was finally begun in 1921, but the undertaking presented such large requirements, and necessitated so much preparatory work, such as the building of roads, telephone lines, etc., that progress has been slow. The limited financial resources of the company, as compared with the magnitude of the project, also handicapped the company greatly, and up to the present time little has been done beyond the construction of some roads and buildings, the sinking of test borings at the sites, excavations for foundations of the dams, and about 500 meters of tunnel work.

The plateau of the Sila, which includes an area of more than 1000 square kilometers, is traversed by a number of rivers, of which the most important are the Neto, Arvo and Ampollino. Its maximum altitude at Botte Donato is 1920 meters, from which it descends gradually to a level of 1250 meters and then drops suddenly to the plain below, which extends from the foot of the mountains to the coast. On this plateau artificial lakes will be created to impound the waters of the rivers in question, and, with a usable head of over 1000 meters, it is estimated that more than 160,000 horse power can be produced.

The total cost of the project is estimated at about 400,000,000 lire (1 lira = \$0.047 at present exchange). The Government will pay a subsidy of 40 lire per horse power developed for 15 years, which, on the basis of the estimate of 168,000 horse power to be developed, would amount approximately to 100,000,000 lire.

Market for Additional Power

One of the problems to be faced will be that of finding a market for the large amount of electric power that will be made available, since the surrounding districts are little developed and the present demand is limited. Commenting on the development of the Sila, a recent article, states that the actual needs of Calabria do not exceed 20,000 horse power, while perhaps 50,000 horse power can be placed in Puglie, where, in addition to the use of electricity for lighting, there is also a demand for electric power from the local industries and for use in connection with irrigation works. It is probable that a part of the power developed may be carried across the Straits of Messina into Sicily and northward into Campania, but there seems no doubt that the production will exceed the present demand in the available markets. However, industrial development invariably follows cheap power, and there is reason to believe that when the power is available the demand will grow to absorb it.

In addition to the generation of electric power, the large volume of water that will be utilized will also be available for irrigation purposes. It is believed that 15,000 hectares (about 40,000 acres) of land, now practically uncultivated, can be reclaimed by irrigation and that a high degree of agricultural development can be reached in the plain of Cotrone, whose soil is said to be extremely fertile.—*Committee Reports.*

Selective Relay System of the 66,000-Volt Ring of the Duquesne Light Company

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Review of the Subject.—*The selective relaying of a high-voltage transmission system gives rise to many interesting problems. This is particularly the case when the system is grounded through a high resistance, as the amount of energy available on ground faults is limited and the ground protection introduces a problem entirely separate from that of the short-circuit protection of the system.*

It is also interesting to note that it is only in recent years that the design of high-voltage large capacity control equipment has been perfected to such a state as to place the protection of high-voltage systems on a par with that of comparatively lower voltage systems. The relay problems involved in the protection of low or high-voltage systems are not materially different except as affected by the equipment available, or by the ever present problem of economics.

The system in question presented no unusul engineering features except as presented by the problem of securing circuit breakers of the required voltage and with sufficient capacity to rupture the large blocks of power presented by short-circuit conditions. This problem was successfully solved by the manufacturer.

A ring system of duplicate feeders lends itself to various relay schemes to secure protection. A number of these schemes was thoroughly investigated and a summary of the conclusions is given, showing the advantages and disadvantages of the schemes considered. These studies showed the advisability of using the scheme of balanced directional relays for short-circuit protection, and selective differential current relays for ground protection, on the 66,000-volt ring of the Duquesne Light Company.

Before putting the relays into service on this system it was decided to make a series of actual service tests on the lines. Accordingly a series of dead grounds were put on the ring and the relays allowed to function to clear the grounded section of line. The dead ground was replaced by a simulated fallen line wire lying on the surface of the ground. This was in turn replaced by a series of arcing grounds accomplished by fusing over a suspension insulator to ground. A total of 28 grounds were thrown on the 66,000-volt ring and successfully cleared by the relays. A description of the tests and a summary of the results are given.

THE 66-kv. transmission system of the Duquesne Light Company surrounds the City of Greater Pittsburgh, enclosing an area of approximately 250 square miles, and supplying electric light and power to an area of approximately 1000 square miles. The ring is somewhat elliptical in shape, one end circle being about twice the diameter of the other. The total circumference of the ring is about 80 miles, and there is one radial tap of 11 miles length. The geographical locations and lengths of the lines may be seen in Fig. 1.

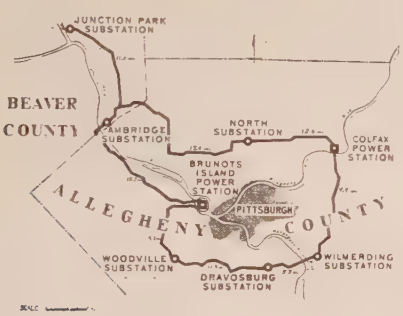

FIG. 1—THE DUQUESNE RING

The ring is made up of parallel lines and is sectionalized at seven points, two of which are generating stations, the remaining five being step down substations. Power is fed into the ring at two points which are approximately diametrically opposite, being located at the two end circles of the ellipse, namely at Colfax and Brunots Island. The number and arrangement of lines in each section are shown in Fig. 2.

The standard section of line consists of seven strands of No. 6 copper wire and has the characteristics of 4/0 copper wire. The lines are carried on steel lta-ticed towers as shown in Fig. 3, each tower carrying two three-phase circuits. The phase wires of each circuit are hung vertically, the spacings being approximately seven feet, eight feet, and fifteen feet respectively.

As previously stated the transmission ring is sectionalized at seven points. Since this sectionalizing involved a heavy cost for switching equipment it was very carefully considered before being decided upon. The high capacity, 30,000 kv-a., of each circuit and the heavy investment involved led to the decision that such sectionalizing was justified.

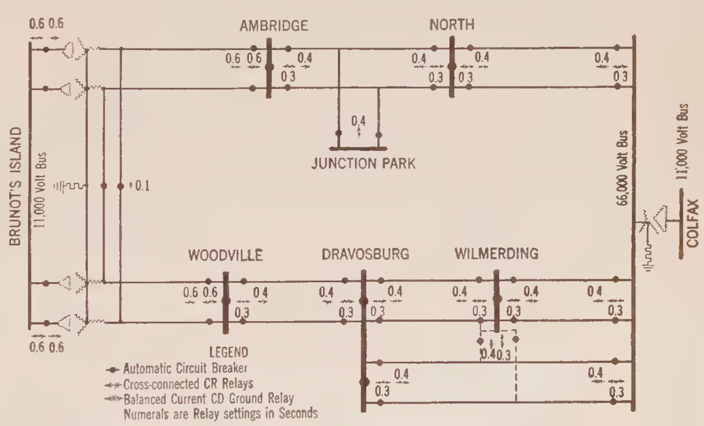

FIG. 2—SCHEMATIC DIAGRAM OF 66 KV. RING SYSTEM SHOWING RELAY PROTECTION

The greater part of the load carried on this system is industrial motor and synchronous railways load. Voltage disturbances in any event lead to unsatis-

Presented at the Spring Convention of the A. I. E. E., Pittsburgh, Pa., April 24-26, 1923.

factory operation to such load and may cause complete interruption. It was therefore decided, since most failures on the 66 kv. system would undoubtedly be grounds, that the neutral of the system should be grounded through a high resistance to minimize disturbance resulting from such failures.

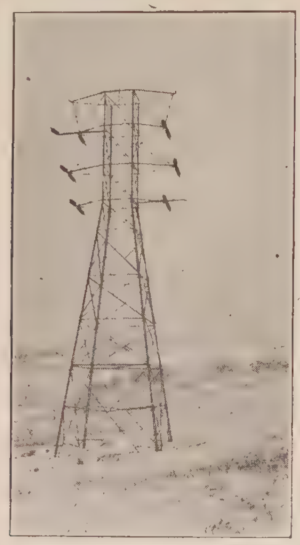

Fig. 3—Typical 66 kv. Line Tower

The conditions imposed introduced certain problems in the relaying as follows:

1. On account of the high-resistance ground, relaying must be provided which would trip out a line on ground current less than full-load current.

2. On account of the heavy industrial motor and synchronous railway load, faults must be eliminated in a minimum time, thus barring out selective time systems.

3. Single line operation must be possible, preferably without additional relays over the number required for parallel line operation.

4. It must be possible to take care of future growth by the addition of parallel lines between any existing stations, or to add radial lines from any ring station, or to introduce additional sectionalizing stations to the present loop, without destroying the existing protection, either schematically or materially.

A study of all of the above factors showed conclusively that the general principle of balanced protection must be used. Such protection always possesses the inherent advantage that it is absolutely unaffected by conditions outside of its own section. This was a fundamental requisite in the problem at hand, which when viewed with the proper perspective, consisted of the proper selective relaying of a basic system frame work. The next problem presented was to choose

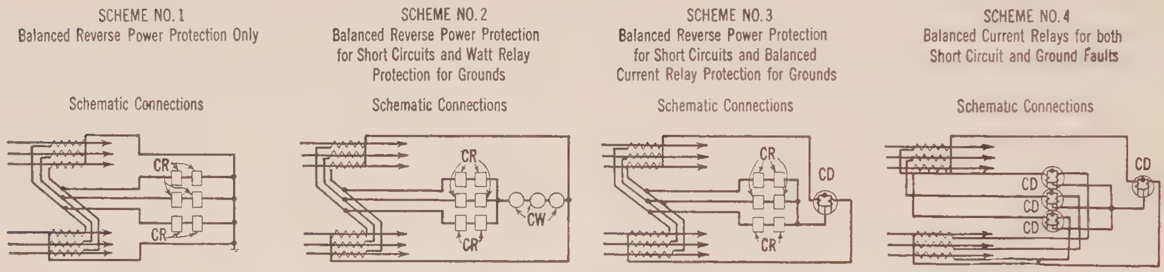

Fig. 4—Comparison of Schemes of Balanced Line Protection

Scheme No. 1

ADVANTAGES
1. Simplicity of wiring and equipment.
2. Directional single-line protection afforded.
3. No additional relays required for ground protection.
4. Requires dead grounded neutral.

DISADVANTAGES
1. Imposes severe voltage unbalance on line which will effect synchronous machines.
2. Severe damage may result as heavy ground current must pass to operate relays.

Scheme No. 2

ADVANTAGES
1. Satisfied all conditions for short-circuit protection for both parallel and single-line operation.
2. Small ground current may be used which ensures the elimination of voltage disturbances.

DISADVANTAGES
1. Additional relays necessary for ground protection, at least one per circuit being required.
2. Wiring is complicated.
3. Extra grounding potential transformer required for one scheme using the watt ground relay.
4. Another scheme used three double contacting watt relays per pair of lines but this scheme does not have a dependable selectivity.

Scheme No. 3

ADVANTAGES
1. Wiring and equipment simple, only one set of relays being required for ground protection of two parallel lines.
2. Satisfies all short-circuit conditions, for both parallel and single-line operation.
3. Small ground current required to operate ground relays.
4. Ground relays very positive in action.

DISADVANTAGES
1. Ground protection is inoperative when ring is open.
2. Ground relays are non-directional for single-line operation.

Scheme No. 4

ADVANTAGES
1. Simple wiring and equipment.
2. Only one ground relay required for ground protection of two parallel lines.
3. No potential connections required.
4. Ground relays very positive in action.

DISADVANTAGES
1. Neither short circuit nor ground protection is operative if ring is open.
2. Single-line operation is not directionally selective.

the proper form of balanced protection. This matter was gone into to some length and Fig. 4, shows a comparison of the schemes considered.

After considerable deliberation Scheme 3 was finally decided upon as fulfilling the most important requirements; namely, the ability to give complete short-circuit protection for both double and single line operation, with the ring either open or closed, with the use of but one set of short-circuit relays; the ability under normal conditions to selectively disconnect grounded sections of line with a minimum of disturbance to the system itself.

The relay equipment as installed at the various stations is shown diagramatically in Fig. 5 and a typical station relay panel is shown in Fig. 6. The short-circuit relays are standard Westinghouse single-contact, type *C R*, 4-12 ampere, reverse power relays, and the ground relays are single-contact 1-3 ampere, selective differen-

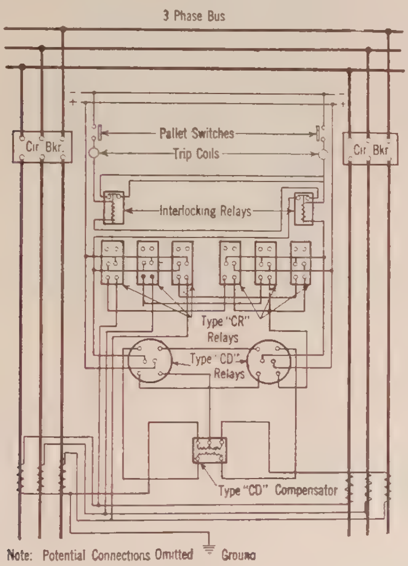

FIG 5

tial current relays. Interlocking relays are installed in the trip circuits of both lines to render the good line non-automatic for a few seconds after the relays have tripped out one end of the defective line. This locks out the trip circuit of the good line until the relays at the opposite end of the section have had time to clear the defective line, thereby preventing the balanced relays from improperly disconnecting the good line of the pair on the end which clears first. On standard line sections the short-circuit relays are set to operate at 0.4 second definite minimum. The 7-ampere current tap is being used on the *C. R.* relays, and the 1-ampere tap on the *C. D.* relays. One 63-ohm grounding resistor is installed at each of the two generating plants. It is possible that this value of resistance may be increased at some later date.

A graphical representation of a typical relay operation on a ground fault is shown in Fig. 7. Sketch No. 7A shows the division of ground currents for a ground fault on line 2 at a point just outside station *M*. With a ground resistance of 63 ohms at each generating station and a neutral voltage of 38,100 volts, this will give between 500 and 600 amperes ground current supplied by each generating station depending upon the

FIG. 6—TYPICAL RELAY PANEL AT RING STATIONS

location of the fault. Using the value of 600 amperes for convenience, it will be noted as shown in Fig. 7A that these currents divide equally until the faulty section is reached, where the shortest section of grounded line will add the fault currents from three lines and pass

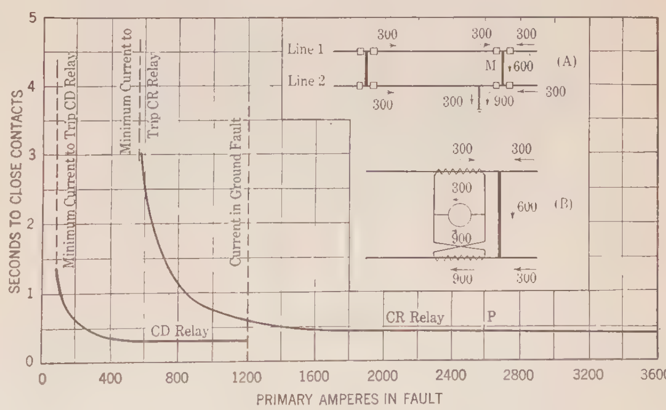

FIG. 7—LOAD TIME CURVES OF *C R* AND *C D* RELAYS

900 amperes to ground, the remaining portion of the grounded line supplying 300 amperes into the fault. This will supply the line relays at the fault with a total of 1200 amperes, since the cross connection of the *C. R.* relays accumulates the currents in the two lines as

shown in Fig. 7B. The ground relays will receive a differential current of 900 − 300 = 600 amperes. Thus both sets of relays will start to close contacts but it will be noted that the line relays receive only sufficient current to cause them to operate on the inverse portion of their time curves, requiring approximately 0.6 second to close contacts. The ground relays, however, operate on the definite minimum portion of their time curves and close contacts in 0.3 second. Assuming 0.4 second for the breaker to open, this makes a total

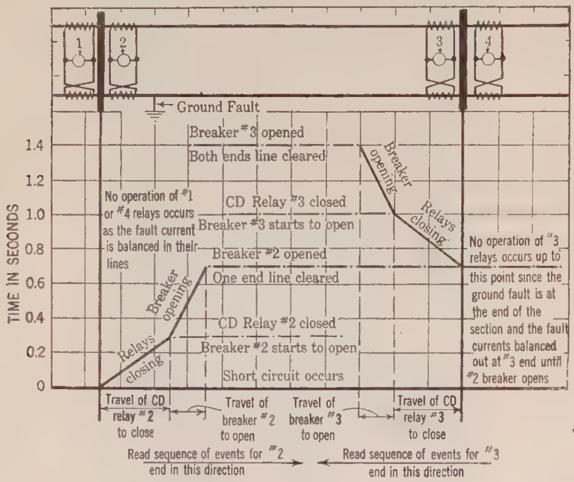

Fig. 7c—Chart Showing Sequence of Events in Clearing Grounded Line

time of 0.7 second to clear one end of the defective line. The opposite end of the grounded line will then start to clear on a similar cycle of operation and thus after 1.4 seconds the grounded line will be entirely disconnected from the remainder of the system. See Fig. 7c.

If for any reason the ground relays fail to respond to the ground fault, provision has been made that the grounding resistors will be short-circuited after a period of approximately 10 seconds following the occurrence of the ground on the system. This places a dead ground on the system which will draw short-circuit current through the line *C. R.* relays and cause them to operate on the definite minimum part of their time curves.

If the fault had been between phase wires instead of to ground, the *C. D.* relays would not have operated but the *C. R.* relays would receive the short-circuit current. For the minimum fault current these relays would operate at a point *P* Fig. 7 on the definite minimum part of the time curve and would close contacts, in 0.4 second. Adding to this the time of opening of the circuit breaker, the defective line would be cleared at one end in 0.8 second. Thus a maximum of 1.6 seconds would isolate the defective line from the system in case of short circuit.

Before putting this relay equipment into operation and in order to prove the effectiveness of the relay scheme, as well as to detect any defects that might exist in the apparatus which would jeopardize service, it was decided to give service tests to the entire installation. The following procedure was accordingly carried out:

One pole of an out-door type *G*-11 circuit breaker was mounted portably and placed as near as possible to the point where it was proposed to apply the ground to the system. The point chosen because of its convenience was just outside the station and a connection was made to the line between the line breaker and the last disconnection point on the line side of the station. Control cables were brought into the station where the grounding apparatus could be manipulated safely and the relay operations observed simultaneously. The ground connection to the grounding breaker was made by two different methods:

1. A connection directly to the grounded side of the 11,000-volt ground resistor, which ground consisted of five interconnected copper plates 2 ft. 6 in. by 3 ft. 4 in. buried five feet under ground and surrounded by charcoal, located at various points around the station.

2. The ground presented by a fallen line wire was simulated by stretching 800 feet of 4/0 bare copper wire over the surface of the ground and this connected to the ground side of the test breaker. The particular point chosen happened to be a plowed field, in the case where it was tried, and a good ground connection was obtained.

To observe the effects of the through fault currents at the other stations on the system, meters were placed

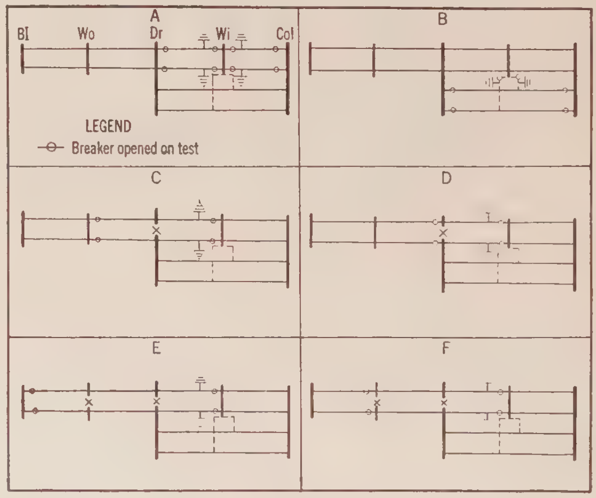

Fig. 8—System Connections for Tests

in the ground and relay circuits of those stations. Thus when the ground was applied, the readings on these meters would give evidence of the ability of these stations to balance out the through fault currents in the cross connection of the current transformers. Prior to the tests the relays were checked for proper operation by means of phantom loads.

In order to test all of the relays on the system with a minimum of test apparatus and connections the tests were made in the following manner:

A grounding breaker was installed at Wilmerding

substation. With all bus sections paralleled at all ring stations, a ground was placed successively on lines 1 and 2 on both sides of the Wilmerding Bus as in Fig. 8A. This operated the *C.R.* and *C.D.* relays on both sides of Wilmerding, on the Wilmerding side of Colfax, and on the Wilmerding side of Dravosburg. In this, and in all following tests, the two sets of relays were tested separately, the one set tripping and the other set being rendered temporarily inoperative. The emergency taps to Wilmerding from the two direct lines between Colfax and Dravosburg, Nos. 3 and 4, were then successively grounded at Wilmerding by means of the grounding breaker, thus operating the *C.R.* and *C.D.* relays at Colfax, Wilmerding and Dravosburg on these two lines. See Fig. 8B.

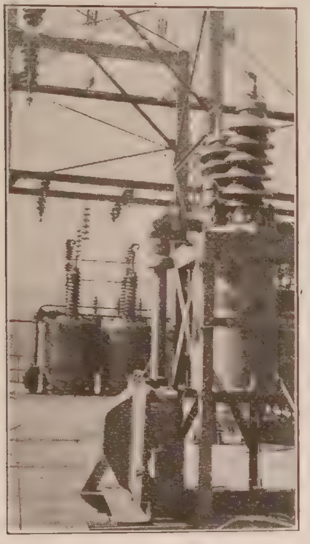

Fig. 9—Grounding Breaker Used on Tests

This completed the test of all relays between Dravosburg and Colfax. The relays between Dravosburg and Brunots Island were then tested as follows:

The bus was split at Dravosburg between lines 1 and 2, thus giving two parallel lines between Wilmerding and Woodville, as in Fig. 8C. The trip circuits of all relays on lines 1 and 2 at Dravosburg were opened. The ground was then applied to lines 1 and 2 successively at Wilmerding and the *C. R.* and *C. D.* relays on the Dravosburg side of Woodville operated, as well as the *C. R.* and *C. D.* relays on the Dravosburg side of Wilmerding. The *C. D.* trip circuits only at Dravosburg were then closed on the Woodville side, and all trip circuits at Woodville opened. See Fig. 8D. The ground at Wilmerding was then applied successively to lines 1 and 2 and the *C. D.* relays only at Dravosburg operated; there was not sufficient feed back from Colfax to test the *C. R.* relays at this same point but their operations was tested by inspection of the movement of the disks of the directional elements. The relays at Brunots Island were then tested by splitting the busses at Dravosburg and Woodville and opening all trip circuits at these stations. See Fig. 8E. By grounding the two lines successively at Wilmerding the *C. R.* and *C. D.* relays at Brunots Island operated. This left only the *C. R.* relays and the *C. D.* relays on the B. I. side of Woodville without test. This test was made by opening the trip circuits on these lines at Brunots Island and closing the trip circuits of the *C. D.* relays only on the Brunots Island side of Woodville which operated when the grounds were applied at Wilmerding. The *C. R.* relays at this point were inspected for proper operations of the directional elements. It was thus possible to test all relays on that side of the ring with the one test set-up at Wilmerding. Some of the apparatus used in these tests are shown in Figs. 9 and 10.

The result of these tests were extremely satisfactory and very conclusive. Several incorrect operations were obtained before correct adjustments were made and defective apparatus detected, but following the correction of these matters perfect operation was recorded.

A total of 28 grounds were applied to the ring in these tests and every operation was correct, both the ground *C. D.* and the line *C. R.* relays being tested as explained previously. By means of operation indicators installed in the relays the operations were checked very exactly. A summary of the test results may be made as follows:

1. The complete scheme of protection was proved to be theoretically correct.

2. Both the short circuit and ground relays, as set up, for final test, operated correctly in every case. No difference in performance was observed or recorded by the operation obtained by grounding the line breaker dead or through the simulated fallen line wire.

Fig. 10—Effect of Ground on 66-kv. Line Wire

3. The ability of all sections to properly pass through short-circuit current was demonstrated.

4. The presence of defective apparatus was detected although the equipment apparently operated satisfactorily on phantom load tests.

5. It is interesting to record that these tests resulted in no injurious effects whatever to either apparatus or service.

The Wave Antenna

A New Type of Highly Directive Antenna

BY HAROLD H. BEVERAGE, CHESTER W. RICE, and EDWARD W. KELLOGG

(*Concluded from page 644*)

Directive Effects for Impulses. The question will naturally arise whether directivity curves calculated for continuous waves, are applicable to the steep wave fronts and pulses of static. The experimental evidence is that they are applicable. It is clear that in the case of the wave antenna, waves on the wire will build up in the direction of travel of the space wave, and relatively feeble waves will reach the opposite end of the antenna, whatever the wave shape or number of waves in the train. As applied to antennas or circuits in which a balance of some sort is employed, to give zero reception for continuous waves from certain directions, the explanation of our experience with static is to be found in the great frequency selectivity of our receiving sets. Harmonic analysis of a pulse would show it to be equivalent to the sum of a large number of trains of waves of different frequencies. Of these the receiving set rejects all but the waves of signal frequency. Another view of the problem is the following:

Any circuit which produces a balance or zero reception for continuous waves of a certain frequency will react to a single pulse in such a way as to cause a second pulse in the opposite direction, simultaneously or a whole number of cycles later, or else a second pulse in the receiver in the same direction as the original, but an odd number of half cycles later. The receiving set has a tuned circuit and a detecting system which integrates over many cycles the effects of the oscillation of the tuned circuit. If the neutralizing pulse is simultaneous with the original, the tuned circuit is unaffected; otherwise the tuned circuit is set into oscillation by the initial pulse, but immediately stopped by the neutralizing pulse. The integrated effect of the brief oscillation is comparatively slight. If there were no neutralizing pulse the tuned circuit would (assuming a reasonably low loss circuit), execute something like a hundred oscillations before the amplitude is reduced to half the initial value.

While we have discussed static as if it consisted of single pulses or of waves of very high decrement, it may well be that some of our static consists of trains of many waves of a fairly constant frequency. The wave antenna, being aperiodic, provides a means of studying some of these disturbances without altering their character. If we insert an ordinary telephone receiver in the ground lead, at one end of a wave antenna, we hear a variety of "crackling" and "sputtering" noises, some of which coincide with the static disturbances in the radio receiving sets. Among these noises is an occasional "ping," or sound of definitely musical character, resembling the sound given out when a bare telephone or telegraph wire is struck a sharp blow. No such sound in the receiver is heard, however, when the outside wire is actually struck.

The manner in which such continuous trains of waves might originate is not evident, but the following analogy is of interest. If you throw a stone into the water, you will note two or three circular waves as soon as the splash has subsided. Three or four seconds later you can count seven or eight waves, of substantially uniform size with a calm area inside, and after some ten seconds there may be a dozen to twenty waves. This analogy may have no significance in connection with ether waves, but it suggests a possibility. If it is true that static contains trains of waves of moderately low decrement, this would in part explain the failure of attempts to improve stray ratio by interior circuits (apart from the frequency selectivity obtainable by highly tuned circuits) and point to the conclusion that increased directivity must be our main reliance for further improvements in receiving through static.

General Engineering Features

Type of Construction. It is brought out in the discussion of the theory that, so far as collecting signal energy is concerned, there is no object in placing the wires of a wave antenna higher than is required for security and to pass obstructions. A high line will show slightly greater wave velocity and less attenuation than a low line, and be less affected by changes in ground conditions or proximity of trees, which sometimes cause sufficient changes in the line constants to give rise to slight reflections. The differences in favor of the higher line, however, are so small that they would rarely warrant the expense of taller poles.

Apart from the importance of a straight line and avoiding proximity of other conductors, the specifications for wave antenna construction might be taken bodily from those written for an open wire copper telephone circuit. Any change in construction or material which will appreciably alter the line impedance and give rise to reflections, should be avoided. Special care should be given to obtaining clean surfaces for making joints, since we are dealing with voltages which, on the average, are hardly a tenth of those developed in ordinary telephone circuits. Sleeve joints are recommended for permanence. The smallest copper wire which will stand the storms will make as satisfactory an antenna as a heavier wire. Good balance, where two wires are used, is important, and for this reason first-class insulation should be provided. We have seen that a single-wire antenna shows lower attenuation and higher velocity than a two wire antenna. For the same reasons, although in less degree, the use

of small wire, and placing the wires near together (if the antenna consists of several wires in multiple) is conducive to high velocity and small attenuation.

Except for temporary or experimental purposes, two-wire antennas are practically always desirable, since they permit adjustments in the station for putting out "back end" disturbances. The use of more wires will, in some cases, collect slightly more energy, but has no other advantage.

Whether a minimum of attenuation and a high velocity are desirable depends primarily on the length of the antenna. For an antenna a wave-length long, the best directive properties are obtained with a velocity between 0.7 and 0.8 of that of light. Higher velocities are desirable for longer antennas and lower velocities for shorter antennas. These considerations may govern the choice of number of wires, or other features of the design. It may even be desirable, in some cases, to reduce the wave velocity of the antenna below the natural value, by loading. The loading may be done by adding series inductance, with the effect of raising the line impedance and reducing the attenuation, as well as reducing the velocity. Slowing down the line by adding capacity to ground will lower the impedance and increase the attenuation. The amount of attenuation experienced on antennas consisting of bare wires on poles, does not appear to affect their directive properties adversely.

Location of Antenna. The land chosen for a wave antenna should be as flat and uniform as possible. The desired location of the receiving station need not control the selection of the location for the antenna. Parallels with other wire lines are to be avoided as far as possible, since the foreign lines, acting as antennas, pick up disturbance from various directions and introduce these into the antenna by induction. There is no simple way of balancing out this induction, for both the lines and the antenna are acting as ground return circuits. It is possible to prevent detrimental effects from adjacent

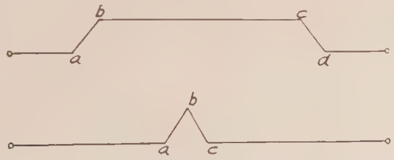

FIG. 78—EQUALLY CROOKED ANTENNAS WHICH ARE NOT EQUIVALENT

lines by loading them so as to prevent their carrying radio frequency currents. The importance of a straight right of way depends in part on the desired over-all velocity, which, in turn, depends on the length employed. Considerable deviations from a straight line affect the directive properties of the antenna, not only by reducing its wave velocity, but by altering the electromotive forces induced in it. For example, the antenna shown in Fig. 78A would receive disturbances from a direction at right angles to the mean line of the antenna, since the electromotive forces in the sections a-b and d-c would by no means neutralize. On the other hand, in Fig. 78B, the sections a-b and c-b, which are affected by disturbances at right angles to the antenna, are a small fraction of a wave length apart, and the effects of the disturbance would nearly neutralize each other in the two sections.

It is important to provide grounds at the ends of the antenna which will not change sufficiently to upset adjustments. A body of water in which several hundred feet of copper wire can be laid is the most desirable terminal for the antenna, but fairly satis-

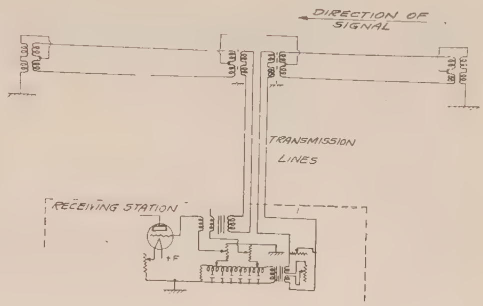

FIG. 79—ARRANGEMENT PERMITTING LOCATION OF RECEIVING STATION AT A DISTANCE FROM THE ANTENNA

factory grounds can be made by burying sufficient lengths of wire. Beverage found on Long Island that, for grounds of this type, it was best to lay the wire in the sod rather than bury it deeper, since the humous of the surface soil retains its moisture better than the sand below. A star consisting of ten or a dozen 100 foot radii of 0.081 in. copper wire laid in this way usually gives a resistance as low as 20 to 40 ohms.

Location of Receiving Station. In the cases of the wave antennas which have so far been built, the receiving station has been located at the end nearest the transmitting station and the signals sent back over the transmission line as illustrated in Fig. 18. Figs. 79 and 80 show arrangements by which the receiving station may be located some distance from the antenna. Effective damping must be provided at the end A, and this can be done either by wasting most of the energy in a resistance at A and transmitting to the station only so much as is necessary for compensation, or by using close coupled transformers of proper ratio to fit the impedance of the circuits which they connect together, and effectively damping the transmission lines in the station. Experience has shown that signals can easily be transmitted a number of miles over open wire lines, with comparatively little loss of intensity, and if we start with signals of such intensity[25] as is usually obtained from a full wave length antenna, there is no perceptible impairment of stray ratio. For the transmission lines which are not a part of the antenna, there is no object in avoiding parallels with other circuits, but they should be transposed frequently

25. The quietness and balance of a two-wire transmission line are not absolute, and if we attempted to transmit very weak signals, they would obviously suffer in stray ratio.

enough to prevent picking up radio frequency currents by induction from other circuits.

Transmission lines will inevitably act as antennas and waves will be built up on them by disturbances traveling parallel with the direction of the transmission lines. If the lines are balanced, these waves will cause no difference of potential between wires, but only potentials to ground. Balanced transformers at the ends, with electrostatic shielding between primary and secondary, will in general suffice to prevent any effects of the parasitic waves from entering the receiver. Cases may arise, however, in which the waves built up on the transmission line are especially strong, making adequate balance difficult. There are several possible measures for reducing the antenna effects of the transmission lines, such as

1. Loading to give low velocity.
2. Sectionalizing with transformers.
3. Draining.

If the loading coils in the two wires are inductively coupled, they may be made to introduce comparatively

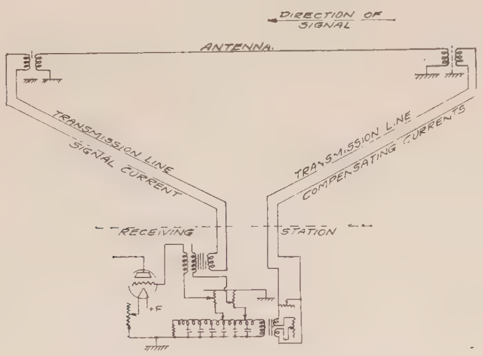

Fig. 80—Alternative to Fig. 79

little inductance in the transmission line and a higher inductance in the ground return line. A short-circuited secondary of suitable resistance will cause high loss to radio frequency currents in the two wires in multiple, but have no effect on the currents in the metallic circuit.

Sectionalizing as shown in Fig. 81 is one of the most effective means of preventing antenna effects in a transmission line. Drains from the neutrals of the transformer are also shown, to dissipate energy and prevent standing waves from building up.

Use of Existing Wires for Antenna. Existing copper wire lines, if uniform throughout the required length, and having the proper bearing, may be utilized as wave antennas. If the wires are in use for telegraph service, coils of 0.075 to 0.1 henry inductance may be used to isolate the part of the line which is to be used as an antenna. The remainder of the line may be drained through condensers if objectionable disturbances get past the coils into the antenna section. Unless the antenna ground is of very low resistance the ground for the drain should be separate, in order that disturbances shall not be carried through to the antenna, owing to common resistance in the ground. Fig. 82 shows a circuit designed to isolate a portion of a telephone line for antenna purposes. This provides both chokes and a drain, and the coils and condensers are proportioned to cause minimum interference with the passage of the telephonic currents. If the grounding of the wires through the 0.3 microfarad condensers makes the telephone line noisy, a 0.2 microfarad condenser in the ground lead will reduce this tendency.

All parallel wires which are not used as part of the antenna should be sectionalized for radio frequency currents, either by coils, or by links of artificial line like that shown in Fig. 82, at intervals of a quarter or a third wave-length or less, of the shortest waves for which the antenna is to be used.

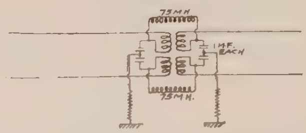

Fig. 81—Sectionalizing Transformer for Transmission Lines, with By-Pass for Direct Current

The principal disadvantages of using telegraph or telephone wires for an antenna are the compromise antenna design which is likely to result, and the difficulty of making tests on the antenna for balance or leakage. The latter applies especially to telegraph lines. If the wires are used for telephony only, large stopping condensers which will permit the telephone ringing currents to pass, may be introduced in series with the wires, at the ends of the antenna, thus permitting direct current tests to be made on the antenna.

Antenna Testing. In any permanent receiving system it should be possible, from the station, to test the continuity and insulation of the antenna and the balance or quietness of the transmission line. Fig. 83 shows an

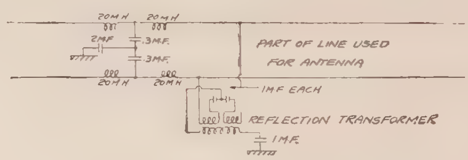

Fig. 82—Isolation of Part of Telephone Line for Use a Antenna

arrangement which Beverage applied to the Riverhead antenna. With the switch S_1 open, the line is insulated from ground and may be tested for leakage by voltmeter or megger. Throwing the switch S_2 to the battery side operates the relay at the far end of the antenna. This cuts out the reflection transformer, and if the transmission line is balanced the receiving set becomes almost entirely quiet. Fig. 84 shows the application of the same method of testing to the case where the receiving station is connected through transmission lines to the antenna. Arrangements for more complete tests are obviously possible, employing polarized relays or selector switches, but the need of any more elaborate testing system has not yet arisen.

Protection. Potentials of several hundred volts are not uncommon on the wave antenna, even with no

storm in the immediate vicinity. All coils which may have to stand these voltages should therefore have substantial insulation. Condensers rated at 1000 volts have been used in the installations at Belmar, Chatham, and Riverhead. Vacuum tube lightning arresters rated at 350 volts are connected between antenna wires and ground at both ends. The switch S_1, in Fig. 83, is closed except during tests, to prevent static potentials from accumulating.

Apparatus Used with Wave Antenna. Some idea of the design of the essential pieces of apparatus which go with the wave antenna, may be of interest.

The reflection transformer for long wave work consists of three 84 turns "pancake" coils. The two outside coils in series constitute the secondary winding which is connected between the antenna wires. The middle coil, which is the primary winding, is connected from ground to the neutral of the secondary. Each coil is approximately 8 in. by 11 in. diameter by 1/2 in.

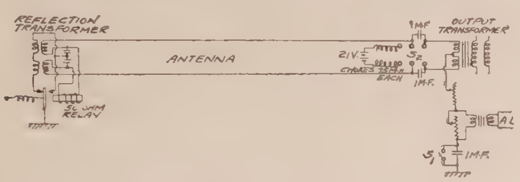

Fig. 83—Arrangements for Insulating and Balance Tests

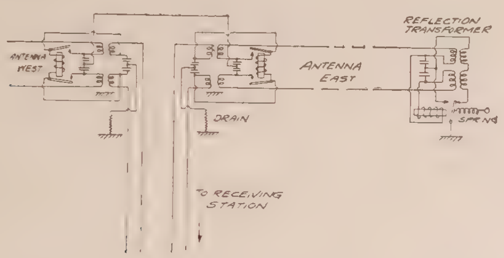

Fig. 84—Relay Circuit for Testing Antenna Over Transmission Lines

thick. The conductor consists of seven strands of 0.010 in. wire with double cotton covering and a cotton braid, thus giving a loose, low-capacity winding. The whole transformer is placed in a wooden box which is filled with paraffin to exclude moisture. The following readings show the inductance:

Primary (84 turns) with secondary open . . . . 2.4 millihenrys
Primary with secondary short-circuited . . . . 0.56 "
Secondary (168 turns) with primary open . . . . 7.5 "
Secondary with primary short-circuited . . . . 1.2 "

An arrangement suggested by Kellogg eliminates the reflection transformer. This consists in grounding one wire of the antenna and leaving the other open-circuited. The signal wave currents built up on the antenna flow in the same direction in the two wires. When the waves reach the end of the antenna, reflections occur in opposite phase on the two wires, so that the waves which travel back toward the receiving station are of opposite sign, and are received by a transformer in the station connected across from wire to wire, exactly as is the case when a reflection transformer is used.

Iron core transformers have been used for the antenna output, or between the transmission line and the receiving set. The core is of 0.0015 in. enamelled iron, and is approximately a square inch in cross-section. The primary, or line winding, is in two equal coils of 60 turns each, placed symmetrically on the core and symmetrically with respect to the secondary windings. There are four secondary windings of 160 turns each with a grounded tinfoil shield between each winding and the next to prevent electrostatic coupling. The secondary windings are connected to the grids of pliotron tubes. A greater step-up ratio might have been employed, with consequent increase in signal strength, but the method of compensation, or "back end balance," did not provide sufficient potentials to permit using any more secondary turns on the output transformer.

Another type of antenna output transformer has been used in which the secondary winding is connected directly in series with a tuned circuit of the receiving set. This transformer was essentially like the one already described, except that the secondary windings were of ten turns each.

The artificial line which is used to adjust phase for the back end compensation, consists of a wooden cylinder 4 inches (10 cm.) in diameter, on which is wound a single layer 36 in. long of 0.0126 enamelled copper wire spaced 46 turns per inch. A tap is brought out, 3/4 in. from the end, and every 1½ inches thereafter, giving a total of 24 taps. A 0.005 microfarad condenser is connected from each winding tap to the common conductor, which forms the other side of the "line." A damping resistance of about 400 ohms, wound on a card, is connected across one end of the line. The line has an electrical length of about 16,000 meters and an intensity loss of about 5 per cent from end to end. Four sliders are provided, with double-contact phosphor bronze springs which bear lightly on the wires of the solenoid.

A trap to prevent interference from the transmitting station at Marion, Mass., which is directly in front of the Riverhead antenna, was used to advantage by Beverage. This consisted in a low-resistance series tuned circuit (about 15 millihenrys and a 0.005 microfarad variable air condenser) connected between the wires of the antenna in the station, thus shunting the primary of the output transformer. This formed such a low-impedance shunt when tuned to Marion's wave length as to practically extinguish his signals. Subsequently, with receiving sets in which additional frequency selectivity was provided, this shunt trap was omitted, but it has a field of usefulness, and the high power factor of the circuit, where it is applied, makes its operation simple and satisfactory.

Application to Short Waves.[26] We have discussed the wave antenna as applied to long wave reception only; that is, to the reception of waves ranging from 7000 to 25,000 meters, used in transoceanic communication. It was in this field that the need of greater directivity in reception seemed most urgent, and in this field that the wave antenna was developed. The writers early demonstrated, in the short wave tests at Schenectady, that the wave antenna functioned in the same way on short waves as on long waves.

The first commercial application to shorter waves was the construction of a 2000-meter antenna at Chatham, Mass., for ship reception. This antenna was built in the summer of 1921 and is used for receiving traffic from ships having 1800 to 3000 meter continuous wave transmitting sets. It was in no wise a disappointment, for it resulted in a great improvement in reception, making it possible to receive ships from practically all the way across the Atlantic.

The next important trial of the wave antenna for short wave reception was during Mr. Paul F. Godley's transoceanic reception tests at Ardrossan, Scotland. Using a wave antenna about 400 meters long, pointed toward the United States, and using the best short wave receiving apparatus obtainable, Mr. Godley copied messages from many American amateur stations, on wave lengths between 200 and 300 meters. He attributed much of his success to his directive receiving antenna. Descriptions of the tests and of the antenna, written by Mr. Godley, were published in the February, 1922, Q. S. T., and the March, 1922, Wireless Age.

Recently the writers have done some experimenting with wave antennas for wave lengths in the 300 to 400 meter range. The advantage of the wave antenna on long waves in giving especially strong signals, is less apparent on short waves. The principal reason for this is that, for short waves, the static antennas or loops which we use as a basis of comparison are much larger in proportion to the wave antenna than is true in the case of antennas used in long wave reception.

The advantage, then, of the wave antenna for receiving waves of 450 meters or less, lies in its directive properties. Many amateurs wish to hear all the stations within range, but where the object is to receive from a certain direction only, and to exclude as much else as possible, the wave antenna will perform its function as well as on long waves.

The form of antenna best for short wave reception is practically the same as for long waves, although it will in general be desirable to reduce the height, in order to lessen the effect of the vertical conductors at the ends. Fig. 85 shows suitable arrangements for short wave reception. The surge impedance for a given type of construction will be slightly less on short waves than on long waves. The double wire antenna with reflection transformer has a decided advantage in convenience compared with a single-wire antenna. The equivalent of the reflection transformer—namely, grounding one wire and leaving the other open-circuited, will, as a rule, be preferred for its simplicity. Rear end compensation by means of the reflection balance is desirable and easily applied. This calls for a series-tuned circuit in series with the surge impedance, as shown in Fig. 85. The resistance should be variable and the capacity reactance and inductive reactance should preferably not exceed about 500 ohms each. For output a coil of about 0.1 millihenry in the ground lead of a single-wire antenna, or, if the reflection transformer system is followed, a 0.2 millihenry coil connected between the two wires of the antenna is suitable. The first tuned circuit of the receiving set may then be coupled to this output coil.

26. For more detailed discussion of the application to short wave reception, see article by H. H. Beverage in Q. S. T., Nov. 1922.

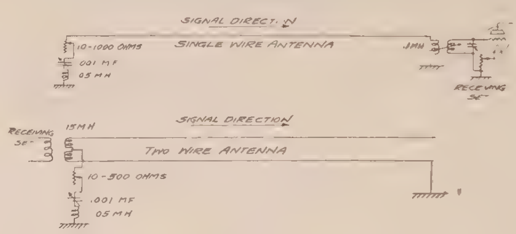

Fig. 85—Arrangements for Short Wave Reception

Appendix A

Typical Operations with Vector Quantities

For additions or subtractions, vectors must be expressed in terms of their components,

$$(a + j\,b) + (c + j\,d) = (a + c) + j\,(b + d)$$
$$(a + j\,b) - (c + j\,d) = (a - c) + j\,(b - d)$$

The vector $a + j\,b$ has a length $\sqrt{a^2 + b^2}$ and an angle $\tan^{-1} b/a$.

Letting φ stand for the angle $\tan^{-1} b/a$, $a = \sqrt{a^2 + b^2}\cos\varphi$ and $b = \sqrt{a^2 + b^2}\sin\varphi$ whence $a + j\,b = \sqrt{a^2 + b^2}\,(\cos\varphi + j\sin\varphi)$.

There are several other ways of expressing a vector in terms of its length and angle $a + j\,b = (\sqrt{a^2 + b^2})\,\epsilon^{j\varphi}$ if φ is expressed in radians or $a + j\,b = (\sqrt{a^2 + b^2})\,\epsilon^{j\,(\varphi^\circ/57.3)}$ if φ° is expressed in degrees. $a + j\,b = \sqrt{a^2 + b^2}\,\underline{/\varphi}$ if we define the symbol $\underline{/\varphi}$ as meaning that the quantity $\sqrt{a^2 + b^2}$ after which it appears is to be multiplied by $\cos\varphi + j\sin\varphi$.

The identity of $\epsilon^{j\varphi}$ and $\cos\varphi + j\sin\varphi$ is most readily shown by expending $\epsilon^{j\varphi}$, $\cos\varphi$, and $\sin\varphi$ in power series, and replacing j^2 by -1. This relation is shown in a number of text books.

The product of two vectors is found by multiplying their lengths together and adding their angles.

Thus $(A\,\underline{/\varphi_1})\,(B\,\underline{/\varphi_2}) = A \times B\,\underline{/\varphi_1 + \varphi_2}$

$$(a + j\,b)\,(c + j\,d) = (\sqrt{a^2 + b^2})\,(c^2 + d^2)\;\underline{/\tan^{-1} b/a + \tan^{-1} d/c}$$

To divide one vector quantity by another we take the quotient of their lengths and the difference of their angles, $\dfrac{A\,\underline{/\varphi_1}}{B\,\underline{/\varphi_2}} = A/B\,\underline{/\varphi_1 - \varphi_2}$.

Multiplication and division may also be performed with the vectors in the form $a + j\,b$, thus $(a + j\,b)\,(c + j\,d) = a\,c + j\,a\,d + j\,b\,c + j^2\,b\,d = (a\ c\ -\ b\ d) + j\,(a\,d + b\,c)$

$$\frac{a + j\,b}{c + j\,d} = \frac{(a + j\,b)}{(c + j\,d)} \times \frac{(c - j\,d)}{(c - j\,d)}$$
$$= \frac{(a\,c + b\,d) + j\,(-\,a\,d + b\,c)}{c^2 + d^2}$$

In the foregoing any component or any angle may have a negative sign.

In the expression $a + j\,b = \sqrt{a^2 + b^2}\,(\cos\varphi + j\sin\varphi)$ where $\varphi = \tan^{-1} b/a$ the quantity $\sqrt{a^2 + b^2}$ taken by itself would have zero phase angle, and the quantity $(\cos\varphi + j\sin\varphi)$ has a phase angle φ and a length unity (since $\cos^2\varphi + \sin^2\varphi = 1$ and therefore $\sqrt{\cos^2\varphi + \sin^2\varphi} = 1$). Multiplying by $\cos\varphi + j\sin\varphi$, or its equivalent $\epsilon^{j\varphi}$ thus simply causes a counter-clockwise rotation or phase advance by the amount of the angle φ. Multiplying by $\epsilon^{-j\varphi}$ or $\cos(-\varphi) + j\sin(-\varphi)$ which is $\cos\varphi - j\sin\varphi$, causes clockwise rotation or phase retardation by the amount of the angle φ.

From the rule for multiplication it follows that to square a vector quantity we square its length and double its angle. Thus $(A\,\underline{/\varphi})^2 = A^2\,\underline{/2\,\varphi}$ and conversely to find the square root of a vector we take the square root of its length and divide its angle by two, $\sqrt{A\,\underline{/\varphi}} = \sqrt{A}\,\underline{/1/2\,\varphi}$.

Differentiation of a vector quantity $\mathbf{A}$, with respect to some variable X, on which $\mathbf{A}$ depends, gives the vector change in $\mathbf{A}$ per unit change in X.

$$\frac{d\,\mathbf{A}}{d\,x} = \frac{\mathbf{A}_2 - \mathbf{A}_1}{x_2 - x_1}$$

in which $\mathbf{A}_2 - \mathbf{A}_1$ is a vector difference, $\mathbf{A}_1$ is the value of $\mathbf{A}$ corresponding to X_1 and A_2 that corresponding to X_2, and X_2 differs from X_1 by an infinitesimal amount.

In Fig. 62A a vector connecting the ends 1 and 2 of the total current vectors, corresponding to $x = 1$ and $x = 2$, would represent $\dfrac{d\,\mathbf{I}}{d\,x}$ corresponding to a value 1.5 for X.

Integration of a vector quantity gives the vector sum of an infiite number of infinitesimal vectors. This process is illustrated, using finite numbers, in Figs. 28 and 33.

Appendix B

Analysis of Action of Wave Antenna

The following treatment of the problem of the wave antenna, was worked out by Mr. Ivar Herlitz or Kellogg's request. Mr. Herlitz was at the time pursuing graduate studies in electrical engineering at Union College as exchange student of the American Scandinavian Foundation. The treatment is given here partly by way of acknowledgment for the substantial assistance derived from Mr. Herlitz's solution of the problem, at an early date in the evolution of the theory of the antenna, and partly because the equations are derived in a radically different manner, and provide a valuable means of checking results as calculated by the expressions given in the body of the paper.

Referring to Fig. 26, x is a distance measured along the antenna from the end A, nearest the source of signals, and l is the total length of the antenna.

As in the discussion given in the paper, the induced voltage per unit length of wire at the point X, is taken as

$$\mathbf{E}_x = \mathbf{E}_0 \cos\theta\,\epsilon^{-j\,\omega\,x\,(\cos\theta)/v}$$

The following new symbols will be used.

$\mathbf{i}$ = current in wire at X

$\mathbf{e}$ = potential of wire at X, with respect to ground.

The potential gradient along wire is the resultant of that due to the passage of current through the line inductance and resistance, and the voltage induced in the wire by the space wave, or

$$\frac{d\,\mathbf{e}}{d\,x} = -\,(R + j\,\omega\,L)\,\mathbf{i} + E_0 \cos\theta\,\epsilon^{-j\,\omega\,x\,(\cos\theta)/v} \tag{52}$$

The current in the wire changes from point to point by the amount of the leakage and charging currents, or

$$\frac{d\,\mathbf{i}}{d\,x} = -\,(G + j\,\omega\,C)\,\mathbf{e} \tag{53}$$

Differentiating (**53**) and solving for $\dfrac{d\,\mathbf{e}}{d\,x}$ gives

$$\frac{d_2\,\mathbf{i}}{d\,x^2} = -\,(G + j\,\omega\,C)\,\frac{d\,\mathbf{e}}{d\,x}$$
$$\frac{d\,\mathbf{e}}{a\,x} = -\,\frac{1}{(G + j\,\omega\,C)}\,\frac{d_2\,\mathbf{i}}{d\,x^2} \tag{54}$$

Substituting this in (**52**) and multiplying through by $-\,(G + j\,\omega\,c)$ gives

$$\frac{d_2\,\mathbf{i}}{d\,x^2} = (R + j\,\omega\,L)\,(G + j\,\omega\,C)\,\mathbf{i}$$
$$-\,(G + j\,\omega\,C)\,\mathbf{E}_0 \cos\theta\,\epsilon^{-j\,\omega\,x\,(\cos\theta)/v} \tag{55}$$

or since $(R + j\,\omega\,L)\,(G + j\,\omega\,C) = \gamma^2$

$$\frac{d_2\,\mathbf{i}}{d\,x^2} = \gamma^2\,\mathbf{i} - (G + j\,\omega\,C)\,\mathbf{E}_0 \cos\theta\,\epsilon^{-j\,\omega\,x\,(\cos\theta)/v} \tag{56}$$

Use trial solution of the form

$$\mathbf{i} = \mathbf{A}\,\epsilon^{\gamma\,x} + \mathbf{B}\,\epsilon^{-\gamma\,x} + \mathbf{D}\,\epsilon^{-j\,\omega\,x\,(\cos\theta/v)} \tag{57}$$

Differentiating (**57**)

$$\frac{d\,\mathbf{i}}{d\,x} = \gamma\,\mathbf{A}\,\epsilon^{\gamma\,x} - \gamma\,\mathbf{B}\,\epsilon^{-\gamma\,x}$$
$$-\,j\,\frac{\omega\cos\theta}{v}\,\mathbf{D}\,\epsilon^{-j\,\omega\,x\,(\cos\theta)/v} \tag{58}$$

$$\frac{d_2\,\mathbf{i}}{d\,x_2} = \gamma^2\,\mathbf{A}\,\epsilon^{\gamma\,x} + \gamma^2\,\mathbf{B}\,\epsilon^{-\gamma\,x}$$
$$-\,\frac{\omega^2\cos^2\theta}{v^2}\,\mathbf{D}\,\epsilon^{-j\,\omega\,x\,(\cos\theta)/v} \tag{59}$$

We next substitute the value of **i** given in (**57**) and the value of $\frac{d_2 \mathbf{i}}{d x^2}$ given in (**59**) in equation (**56**)

$$\gamma^2 \mathbf{A}\,\epsilon^{\gamma x} + \gamma^2 \mathbf{B}\,\epsilon^{-\gamma x} - \frac{\omega^2 \cos^2\theta}{v^2}\mathbf{D}\,\epsilon^{-j\,\omega\,x\,(\cos\theta)/v}$$
$$= \gamma^2 \mathbf{A}\,\epsilon^{\gamma x} + \gamma^2 \mathbf{B}\,\epsilon^{-\gamma x} + \gamma^2 \mathbf{D}\,\epsilon^{-j\,\omega\,x\,(\cos\theta)/v}$$
$$- (G + j\,\omega\,C)\,\mathbf{E}_0 \cos\theta\,\epsilon^{-j\,\omega\,x\,(\cos\theta)/v}$$

from which

$$\mathbf{D}\left(\gamma^2 + \frac{\omega^2\cos^2\theta}{v^2}\right) = (G + j\,\omega\,C)\,\mathbf{E}_0\cos\theta$$

$$\mathbf{D} = \frac{(G + j\,\omega\,C)\,\mathbf{E}_0\cos\theta}{\gamma^2 + \dfrac{\omega^2\cos^2\theta}{v^2}} \qquad (\mathbf{60})$$

Using this value of D in (**57**), we have as the general expression for current

$$\mathbf{i} = \mathbf{A}\,\epsilon^{\gamma x} + \mathbf{B}\,\epsilon^{-\gamma x} + \frac{(G + j\,\omega\,C)\,\mathbf{E}_0\cos\theta}{\gamma^2 + \dfrac{\omega^2\cos^2\theta}{v^2}}\,\epsilon^{-j\,\omega\,x\,(\cos\theta)/v} \qquad (\mathbf{61})$$

The constants **A** and **B** depend on the terminal impedance and we must find an expression for the voltage **e**, as well as the current **i**, in order to evaluate them. From (**53**)

$$\mathbf{e} = -\frac{1}{(G + j\,\omega\,C)}\frac{d\,\mathbf{i}}{d\,x}$$

in which we may substitute the value of $\frac{d\,\mathbf{i}}{d\,x}$ given in (**58**) using the value given in (**60**) for **D**

$$\mathbf{e} = \frac{-\gamma\,\mathbf{A}\,\epsilon^{\gamma x}}{G + j\,\omega\,C} + \frac{\gamma\,\mathbf{B}\,\epsilon^{-\gamma x}}{G + j\,\omega\,C} + \frac{j\dfrac{\omega\cos\theta}{v}\,\mathbf{E}_0\cos\theta}{\gamma^2 + \dfrac{\omega^2\cos^2\theta}{v^2}}\,\epsilon^{-j\,\omega\,x\,(\cos\theta)/v}$$

Since $\frac{\gamma}{G + j\,\omega\,c} = \mathbf{Z}$, the expression for **e** becomes.

$$\mathbf{e} = -\mathbf{Z}\,\mathbf{A}\,\epsilon^{\gamma x} + \mathbf{Z}\,\mathbf{B}\,\epsilon^{-\gamma x} + \frac{j\dfrac{\omega\cos\theta}{v}\,\mathbf{E}_0\cos\theta}{\gamma^2 + \dfrac{\omega^2\cos^2\theta}{v^2}}\,\epsilon^{-j\,\omega\,x\,(\cos\theta)/v} \qquad (\mathbf{62})$$

For an antenna with non-reflecting ends, or in other words, with the surge impedance at each end,

$\mathbf{e} = -\mathbf{Z}\,\mathbf{i}$ for $x = 0$

$\mathbf{e} = +Z\,\mathbf{i}$ for $x = l$

Using the expresssions for **i** and **e** given in (**61**) and (**62**) we set $x = 0$ and equate $-\mathbf{Z}\,\mathbf{i}$ to **e**, and have

$$-\mathbf{Z}\,\mathbf{A} - \mathbf{Z}\,\mathbf{B} - \mathbf{Z}\frac{(G + j\,\omega\,C)\,\mathbf{E}_0\cos\theta}{\gamma^2 + \dfrac{\omega^2\cos^2\theta}{v^2}}$$

$$= -\mathbf{Z}\,\mathbf{A} + \mathbf{Z}\,B + \frac{j\dfrac{\omega\cos\theta}{v}\,\mathbf{E}_0\cos\theta}{\gamma^2 + \dfrac{\omega^2\cos^2\theta}{v^2}}$$

whence

$$-2\,\mathbf{Z}\,\mathbf{B} = \frac{\mathbf{E}_0\cos\theta}{\gamma^2 + \dfrac{\omega^2\cos^2\theta}{v^2}}\left\{ j\frac{\omega\cos\theta}{v} + \mathbf{Z}\,(G + j\,\omega\,C) \right\}$$

and since $\mathbf{Z}\,(G + j\,\omega\,c) = \gamma$

$$\mathbf{B} = -\frac{\mathbf{E}_0\cos\theta}{2\,\mathbf{Z}}\,\frac{\gamma + j\dfrac{\omega\cos\theta}{v}}{\gamma^2 + \dfrac{\omega^2\cos^2\theta}{v^2}}$$

$$= -\frac{\mathbf{E}_0\cos\theta}{2\,\mathbf{Z}\left[\gamma - j\dfrac{\omega\cos\theta}{v}\right]} \qquad (\mathbf{63})$$

Next setting $x = l$ in (**61**) and (**62**) and equating $+\mathbf{Z}\,\mathbf{i}$ to **e** we have

$$\mathbf{Z}\,\mathbf{A}\,\epsilon^{\gamma l} + \mathbf{Z}\,\mathbf{B}\,\epsilon^{-\gamma l} + \mathbf{Z}\frac{(G + j\,\omega\,C)\,E_0\cos\theta}{\gamma^2 + \dfrac{\omega^2\cos^2\theta}{v^2}}\,\epsilon^{-j\,\omega\,l\,(\cos\theta)/v}$$

$$= -\mathbf{Z}\,\mathbf{A}\,\epsilon^{\gamma l} + \mathbf{Z}\,\mathbf{B}\,\epsilon^{-\gamma l} + \frac{j\dfrac{\omega\cos\theta}{v}\,\mathbf{E}_0\cos\theta}{\gamma^2 + \dfrac{\omega^2\cos^2\theta}{v^2}}\,\epsilon^{-j\,\omega\,l\,(\cos\theta)/v}$$

$$2\,\mathbf{Z}\,\mathbf{A}\,\epsilon^{\gamma l} =$$
$$\frac{\mathbf{E}_0\cos\theta\,\epsilon^{-j\,\omega\,l\,(\cos\theta)/v}}{\gamma^2 + \dfrac{\omega^2\cos^2\theta}{v^2}}\left[j\frac{\omega\cos\theta}{v} - \mathbf{Z}\,(G + j\,\omega\,C)\right].$$

$$= -\frac{\mathbf{E}_0\cos\theta\,\epsilon^{-j\,\omega\,l\,(\cos\theta)/v}}{\gamma^2 + \dfrac{\omega^2\cos^2\theta}{v^2}}\left[\gamma - j\frac{\omega\cos\theta}{v}\right]$$

$$= -\frac{\mathbf{E}_0\cos\theta\,\epsilon^{-j\,\omega\,l\,(\cos\theta)/v}}{\gamma + j\dfrac{\omega\cos\theta}{v}}$$

$$\mathbf{A} = \frac{-\mathbf{E}_0\cos\theta\,\epsilon^{-j\,\omega\,l\,(\cos\theta)/v}}{2\,\mathbf{Z}\,\epsilon^{\gamma l}\left(\gamma + j\dfrac{\omega\cos\theta}{v}\right)}$$

$$= -\frac{\mathbf{E}_0\cos\theta\,\epsilon^{-(\gamma + j\,\omega\,l\,(\cos\theta)/v}}{2\,\mathbf{Z}\left(\gamma + j\dfrac{\omega\cos\theta}{v}\right)} \qquad (\mathbf{64})$$

With these values for **A** and **B** and with $\gamma/\mathbf{Z}$ substituted for $G + j\,\omega\,C$, equation (**61**) for current becomes

$$\mathbf{i} = \mathbf{E}_0\cos\theta\left\{ \frac{-\epsilon^{-(\gamma + j\,\omega\,l\,(\cos\theta)/v}}{2\,\mathbf{Z}\left(\gamma + j\dfrac{\omega\cos\theta}{v}\right)}\,\epsilon^{\gamma x} - \frac{1}{2\,\mathbf{Z}\left(\gamma - j\dfrac{\omega\cos\theta}{v}\right)}\,\epsilon^{-\gamma x} + \frac{\gamma\,\epsilon^{-j\,\omega\,l\,(\cos\theta)/v}}{\mathbf{Z}\left(\gamma^2 + \dfrac{\omega^2\cos^2\theta}{v^2}\right)} \right\} \qquad (\mathbf{65})$$

The receiver end current is found by letting $x = l$ in (65) which gives

$$\mathbf{i}_b = \mathbf{E}_0 \cos\theta \left\{ \frac{-\epsilon^{-(\gamma + j\,\omega\, l\,(\cos\theta)/v}}{2\,\mathbf{Z}\left(\gamma + j\,\frac{\omega\cos\theta}{v}\right)}\,\epsilon^{\gamma l} - \frac{\epsilon^{-\gamma l}}{2\,\mathbf{Z}\left(\gamma - j\,\frac{\omega\cos\theta}{v}\right)} + \frac{\gamma\,\epsilon^{-j\,\omega\,l\,(\cos\theta)/v}}{\mathbf{Z}\left(\gamma^2 + \frac{\omega^2\cos^2\theta}{v^2}\right)} \right\}$$

$$= \frac{E_0\cos\theta}{2\,\mathbf{Z}} \left\{ \frac{-\epsilon^{-j\,\omega\,l\,(\cos\theta)/v}}{\gamma + j\,\frac{\omega\cos\theta}{v}} - \frac{\epsilon^{-\gamma l}}{\gamma - j\,\frac{\omega\cos\theta}{v}} + \frac{2\,\gamma\,\epsilon^{-j\,\omega\,l\,(\cos\theta)/v}}{\left(\gamma + j\,\frac{\omega\cos\theta}{v}\right)\left(\gamma - j\,\frac{\omega\cos\theta}{v}\right)} \right\}$$

$$= \frac{\mathbf{E}_0\cos\theta}{2\,\mathbf{Z}}\,\frac{\epsilon^{-j\,\omega\,l\,(\cos\theta)/v}}{\left(\gamma - j\,\frac{\omega\cos\theta}{v}\right)} \times \left\{ -\frac{\left(\gamma - j\,\frac{\omega\cos\theta}{v}\right)}{\gamma + j\,\frac{\omega\cos\theta}{v}} - \epsilon^{-\gamma l}\,\epsilon^{+j\,\omega\,l\,(\cos\theta)/v} + \frac{2\,\gamma}{\gamma + j\,\frac{\omega\cos\theta}{v}} \right\}$$

$$= \frac{\mathbf{E}_0\cos\theta\,\epsilon^{-j\,\omega\,l\,(\cos\theta)/v}}{2\,\mathbf{Z}\left(\gamma - j\,\frac{\omega\cos\theta}{v}\right)} \times \left\{ \frac{\gamma + j\,\frac{\omega\cos\theta}{v}}{\gamma + j\,\frac{\omega\cos\theta}{v}} - \epsilon^{-(\gamma - j\,\omega\,l\,(\cos\theta)/v} \right\}$$

$$= \frac{\mathbf{E}_0\cos\theta\,\epsilon^{-j\,\omega\,l\,(\cos\theta)/v}}{2\,\mathbf{Z}\left(\gamma - j\,\frac{\omega\cos\theta}{v}\right)} \{1 - \epsilon^{-(\gamma - j\,\omega\,l\,(\cos\theta)/v}\}$$

$$= \frac{\mathbf{E}_0\cos\theta\,\epsilon^{-j\,\omega\,l\,(\cos\theta)/v}}{2\,\mathbf{Z}\,[\,\alpha + j\,\beta\,(1 - n\cos\theta)\,]} \times \{1 - \epsilon^{-[\alpha + j\,\beta\,(1 + n\cos\theta)\,]\,l}\} \qquad (66)$$

The back end current is found by setting $x = 0$ in (65) which gives

$$\mathbf{i}_a = \mathbf{E}_0\cos\theta \left\{ \frac{-\epsilon^{-[\gamma + j\,\omega\,l\,(\cos\theta)/v}}{2\,\mathbf{Z}\left(\gamma + j\,\frac{\omega\cos\theta}{v}\right)} - \frac{1}{2\,\mathbf{Z}\left(\gamma - j\,\frac{\omega\cos\theta}{v}\right)} + \frac{\gamma}{\mathbf{Z}\left(\gamma + j\,\frac{\omega\cos\theta}{v}\right)\left(\gamma - j\,\frac{\omega\cos\theta}{v}\right)} \right\}$$

$$= \frac{\mathbf{E}_0\cos\theta}{2\,\mathbf{Z}\left(\gamma + j\,\frac{\omega\cos\theta}{v}\right)} \left\{ -\epsilon^{-[\gamma + j\,\omega\,(\cos\theta)/v\,]\,l} - \frac{\gamma + j\,\frac{\omega\cos\theta}{v}}{\gamma - j\,\frac{\omega\cos\theta}{v}} + \frac{2\,\gamma}{\gamma - j\,\frac{\omega\cos\theta}{v}} \right\}$$

$$= \frac{\mathbf{E}_0\cos\theta}{2\,\mathbf{Z}\left(\gamma + j\,\frac{\omega\cos\theta}{v}\right)} \{1 - \epsilon^{-[\gamma + j\,\omega\,(\cos\theta)/v\,]\,l}\}$$

$$= \frac{\mathbf{E}_0\cos\theta}{2\,\mathbf{Z}\,[\alpha + j\,\beta\,(1 + n\cos\theta)\,]} \times \{1 - \epsilon^{-[\alpha + j\,\beta\,(1 + n\cos\theta)\,]\,l}\} \qquad (67)$$

Appendix C

List of Symbols

Symbols in heavy faced type, as **I**, **E**, **Z** stand for vector quantities.

L = Series inductance of antenna conductors, henrys per kilometer.

C = Shunt capacity of antenna, farads per kilometer

R = Effective series resistance of antenna, ohms per kilometer

G = Leakage conductance to ground, mhos for one kilometer, (effective value at high frequency)

$\mathbf{Z}$ = Characteristic or surge impedance of antenna

$\mathbf{Z} = \sqrt{\frac{R + j\,\omega L}{G + j\,\omega C}}$ or for most purposes at radio frequency $Z = \sqrt{L/C}$

γ = Propagation constant for antenna

$\gamma = \sqrt{(R + j\,\omega L)\,(G + j\,\omega C)}$

α = Attenuation constant per kilometer = real part of γ. If ωL is large compared with R, and ωc large compared with G, $\alpha = R/2\,\sqrt{C/L} + G/2\,\sqrt{C/L}$ approximately

$j\,\beta$ = Imaginary component of γ, or β = Wave length constant of Antenna. $\gamma = \alpha + j\,\beta$. For most purposes at radio frequency $\beta = \omega\sqrt{L\,C}$ approximately

u = Antenna wave velocity, kilometers per second $u = \omega/\beta$ or $u = 1/\sqrt{L\,C}$ approximately

v = Velocity of space waves = Velocity of light = 3×10^5 kilometers per second

n = Velocity ratio of antenna = u/v

f = frequency of signal waves, cycles per second

λ = Signal wave length = $\frac{3 \times 10^5}{f}$ kilometers

$\omega = 2\,\pi\,f$

ϵ = Base of natural logarithms = 2.718 $\epsilon^x = 10^{0.4343\,x}$

l = Length of antenna in kilometers

θ = Angle between direction of signal and direction of antenna

E_0 = Measure of signal intensity = Induced volts per kilometer in horizontal conductor parallel to signal direction

I_b = Current at receiver end of antenna (both ends of antenna assumed to be damped by surge impedance)

I_a = Current at back end of antenna (both ends assumed damped)

ρ = Specific resistance of earth, ohms for one centimeter cube.

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Standardized Insulator Tests

By the Insulator Subcommittee of the A. I. E. E. Standards Committee

CONTENTS

At the Pacific Coast Convention of the American Institute of Electrical Engineers, held in Portland, Oregon, July 1920, the following resolutions were passed:

Whereas, there exists at present a decided lack of uniformity in methods of testing and ratings adopted by the manufacturers of pin type insulators, affecting recommended line voltages and rated dry and wet flashover values; and

Whereas, the United States Bureau of Standards in the National Electric Code for overhead line construction has specified minimum values of flashover voltages on insulators used for transmission and distribution lines, but has not indicated the method of determining these values; therefore

Be It Resolved: That the members of the A. I. E. E. in session of the Pacific Coast Convention recommend that steps be taken in the near future by the Standardization Committee of the Institute to properly standardize methods of testing and rating pin type insulators, in order to obtain uniform values of flashover voltages for similar types.

Be It Further Resolved: That a copy of this resolution be sent to the United States Bureau of Standards, Washington, D. C.

As a result of this action, the Standards Committee of the American Institute of Electrical Engineers in October 1920, appointed a subcommittee* to take up the work as outlined and advised it as follows:

It will be observed that the resolution of the Pacific Coast Convention refers more particularly to pin type insulators, but it is desirable for this subcommittee to give attention to the question of all types of insulators for transmission lines.

As a result of the work of this subcommittee certain specifications covering the usual design tests have been drawn up and recommended to the Standards Committee. It is considered desirable, however, to obtain as much criticism as may be possible from all insulator users, before any final standardization is authorized, and it is with the desire of stimulating such criticism that the proposed specifications are presented herewith.

In undertaking to establish specified methods of conducting these tests, it was necessary to carry out investigations into the effect of test conditions. Such investigations were made at one of the insulator factories. It was found for instance that in the case of the test conductor for pin type insulators, laboratory tests demonstrated that on insulators having a dry flashover value ranging from 60 to 200 kv., with a test conductor less than 4 ft. (1.22 meter) long, the flashover voltage diminished with the conductor length, while for longer lengths the flashover voltage remained constant. A minimum length of 4 ft. (1.22) was therefore established. In general, where similar dimensions are given in these specifications they have been determined by the same sort of investigation.

In preparing these specifications a considerable lack of uniformity in definitions of accepted terms was encountered and, consequently, certain definitions have been proposed for standardization and these are published herewith. It should be remembered that these specifications are not intended to apply to routine factory tests. The Insulator Subcommittee is still giving consideration to this subject, and will welcome criticisms and suggestions leading to improvement in the form or subject matter of the specifications.

Pin Insulator Design Test Specifications as Tentatively Proposed

Definitions

The following terms are in common use and it is believed merit an exact definition or specification. The subcommittee therefore suggests the following:

A pin insulator is a complete insulator, consisting of one insulating member or an assembly of such members without tie wires, clamps, thimbles or other accessories, the whole being of such construction that when mounted on an insulator pin, it will afford insulation and mechanical support to a conductor.

A shell is a single insulating member without cement or other connecting devices.

Dry flashover voltage is the voltage at which the air surrounding a clean dry insulator or shell breaks down between electrodes, with the formation of a sustained

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*This subcommittee now includes the following members:

R. E. Argersinger	Electrical Engr., Stone & Webster, Inc.
A. O. Austin	The Ohio Insulator Co.
A. F. Bang	Testing Engr., Pennsylvania Water & Pr. Co.
H. A. Barre	Executive Engr., Southern Calif. Ed. Co.
S. L. Case	Westinghouse Elec. & Mfg. Co.
G. I. Gilchrest	Westinghouse Elec. & Mfg. Co.
K. A. Hawley	Chief Engr., Locke Insulator Mfg. Co.
R. P. Jackson	Westinghouse Elec. & Mfg. Co.
P. Junkersfeld (Chairman)	McClellan & Junkersfeld, Inc.
A. H. Lawton	Consumers Power Co.
J. C. Martin	McGraw-Hill Co., Inc.
R. H. Marvin	The R. Thomas & Sons Co.
A. H. Moore	General Electric Co.
W. D. A. Peaslee	Chief Engr., Belden Mfg. Co.
F. W. Peek, Jr.	General Electric Co.
H. J. Ryan	Leland Stanford, Jr., University.
A. E. Silver	Electric Bond & Share Co.

Presented at the Spring Convention of the A. I. E. E., Pittsburgh, Pa., April 24-26, 1923.

arc, the test being made as described under "Dry Flashover Test."

Wet flashover voltage is the voltage at which the air surrounding a clean wet insulator or shell breaks down between electrodes with the formation of a sustained arc, the test being made as described under "Wet Flashover Test."

Puncture voltage is the voltage at which an insulator or shell is electrically punctured when subjected to a gradually increasing voltage, the test being made as described under "Puncture Voltage Test."

The ultimate mechanical strength of a pin insulator is the load in pounds at which the insulator fails either electrically or mechanically, voltage and mechanical stress being applied simultaneously as described under "Ultimate Mechanical Strength Test."

Dry Flashover Test (Design Test)

Dry flashover test shall be performed with the pin insulator mounted in a vertical position on a steel pin of circular section 1 in. (2.54 cm.) in diameter mounted on a cross-arm, and of such length that the ratio of the shortest distance from the edge of the head around the insulator to the cross-arm, to the shortest distance from the edge of the head around the insulator to the pin, shall be 1.25. The cross-arm shall be of iron pipe, preferably grounded, not less than 3 in. (7.63 cm.) and not more than 5 in. (12.7 cm.) in diameter and shall extend at least 3 ft. (0.914 m.) on either side of the center line of the insulator pin. The head of the insulator shall be fitted with a straight, smooth metallic rod or tube not less than ½ in. (1.27 cm.) in diameter extending in a direction at right angles to the cross-arm and at least 2 ft. (0.609 m.) in either direction from the center line of the insulator head. This rod shall be secured in the upper groove by means of at least one turn of wire not smaller than No. 8 A. w. g. placed in the side tie wire groove.

The character of the testing equipment and method of measuring voltage shall conform to the Standardization Rules of the A. I. E. E.

The test shall be performed by applying voltage between the rod fastened to the head and the steel pin, and raising it at a uniform rate of approximately five thousand (5000) volts per second to a value at which dry flashover occurs.

Records shall be made of barometric pressure, air temperature and humidity.

Wet Flashover Test (Design Test)

The testing arrangement shall be the same as in the dry flashover test with the addition of equipment to provide a finely divided uniform spray at an angle of 45 deg. from the vertical and at a rate of 0.2 in. (5.07 mm.) per minute. The water shall have a resistance of from 3000 to 6000 ohms per in. cube (7620 to 15,250 ohms per cm. cube) and shall be delivered to the spray nozzle at a pressure of not less than 35 and not more than 50 pounds per sq. in. (2.46 to 3.51 kg. per sq. cm.) measured at the nozzle. The vertical and horizontal dimensions of the vertical area sprayed shall be measured in a plane through the vertical axis of the insulator and shall be 1.75 times the corresponding over-all projected dimensions of the insulator. The precipitation shall be determined by measurements taken, with the insulator removed, at the location of the top, center and bottom of the vertical axis of the insulator when in its test position. Individual measurements shall show a variation of not more than 25 per cent from the mean of the three measurements.

Methods of applying and measuring voltage and of recording data, shall be the same as for the "Dry Flashover Test."

Puncture Test (Design Test)

In making this test the insulator shall be immersed in oil with the pin hole, line and tie wire grooves filled with conducting material, voltage being applied between the pin hole and tie wire.

Voltage shall be applied at not more than three-fourths of the dry flashover voltage and raised at a uniform rate of approximately 5000 volts per second for insulators having an average puncture of 200,000 volts or less, and at a uniform rate of 10,000 volts per second for insulators having an average puncture voltage of more than 200,000 volts, voltage being raised until puncture occurs.

Methods of applying and measuring voltage and of recording data shall be the same as in the "Dry Flashover Test."

Corona Formation Voltage (Design Test)

The testing arrangement shall be the same as for the dry flashover test, using a darkened room. A voltage sufficient to cause streamers shall be applied and slowly lowered until all brush discharges disappear. The point of disappearance shall be the corona voltage.

Methods applying and measuring voltage and of recording data shall be the same as in the "Dry Flashover Test."

Ultimate Mechanical Strength Test (Design Test)

This test shall be performed in a suitable insulated testing machine where mechanical loads up to the ultimate rupture point can be applied simultaneously with a potential 15 per cent below the dry flashover voltage at a frequency not greater than 60 cycles. During the test the mechanical load shall be increased at the rate of 2000 lb. (907.2 kg.) per minute until puncture takes place. For pin type insulators, the mechanical load shall be applied at right angles to the central axis, with a suitable metal supporting pin which will not materially deflect or bend under the maximum stress imposed. Attachment shall be made to the tie wire groove by means of a steel cable loop or bridle.

Methods of applying and measuring voltage and of

recording data shall be the same as in the "Dry Flashover Test."

Suspension Insulator Proposed Test Specification

Definitions

The following definitions are proposed:

A suspension insulator unit is a shell assembled with its necessary attaching members.

A string consists of two or more units connected in series.

Dry Flashover Test

Dry flashover test shall be performed with the insulator, unit or string, suspended vertically by the makers' standard cross-arm suspension hardware carried at the end of a grounded wire or suitable conductor suspended so that the vertical distance from the uppermost point of the insulator hardware to the supporting structure shall not be less than 3 ft. No other grounded structure shall be nearer than 3 ft. to any part of the unit or string. The insulator pin, or corresponding fitting, shall carry an inverted pipe tee made of ¾-in. pipe, the head of the tee being not less than 6 ft. long, the stem of the tee being coupled at the middle point of the head and having such a length that the distance from the upper surface of the horizontal head to the lowest edge of the porcelain shall not exceed 0.7 of the diameter of the lowest unit.

Potential shall be applied between the stem of the pipe tee and the grounded suspension by raising the voltage at the rate of approximately 5000 volts per second to a value at which dry flashover occurs. Records shall be made of barometric pressure, air temperature and humidity.

The character of the testing equipment and method of measuring voltage shall conform to the Standards of the A. I. E. E.

Wet Flashover Test

The wet flashover test shall be performed using the same general arrangement as in the dry flashover test with the addition of equipment to provide a finely divided and reasonably uniform spray at an angle of 45 deg. from the vertical and at the rate of 2/10 in. (5.07 mm.) per minute. The water shall have a resistance of from 3000 to 6000 ohms per inch cube (7620 to 15,250 ohms per cm. cube) and shall be delivered to the spray nozzle at a pressure of not less than 35 and not more than 50 lb. per square inch (2.46 to 3.51 kg. per sq. cm.) measured at the nozzle. The vertical and horizontal dimensions of the vertical area sprayed shall be measured in a plane through the vertical axis of the unit or string and shall be 1.75 times the corresponding over-all projected dimensions of the unit or string. Precipitation shall be determined by measurements, taken with the unit or string removed, at the location of the top, center and bottom of the vertical axis of the unit or string when in its test position. Individual measurements shall show a variation of not more than 25 per cent from the mean of the three measurements.

Methods of applying and measuring voltage and of recording data shall be the same as for the dry flashover test.

Puncture Test

Puncture test shall be performed with the insulator or unit immersed in oil, voltage being applied between the cap and stud or corresponding metal fittings. Methods of applying voltage and recording data shall be the same as in the dry flashover test except that voltage application shall be begun at not more than ¾ of the dry flashover voltage.

Report of Insulator Subcommittee of the Standard Committee, A. I. E. E. for 1922-1923

The Insulator Subcommittee, Working Committee No. 3, has held four meetings, as follows:

December 8, 1922	March 9, 1923
February 2, 1923	April 6, 1923

all at Institute Headquarters, New York, N. Y.

The subcommittee has continued the study, begun last year, of the factor of safety to be recommended between line voltage and dry flashover of the insulator.

It has tabulated the data received from 27 operating companies in reply to questionnaire sent out.

The subcommittee recommends that for the present this data be used in selecting pin insulators.

The subcommittee suggests that with steel supports or grounded pins it is desirable to use the higher factors of safety while with ungrounded pins on wood poles the lower factors of safety may be justified. At present the subcommittee is not prepared to recommend what this variation should be. A discussion of the entire situation is invited.

For convenience the following table gives flashover voltages corresponding to various line voltages, as taken from this data:

Line Kv.	Flashover Kv. Minimum	Average	Maximum
11	68	88	110
13.2	..	91	..
22	90	110	121
33	109	124	142
44	163	172	180
60	186	192	222
66	179	185	198

The discrepancy between the tests for 60 kv. and 66 kv. is probably due to lack of sufficient data.

In this connection, the subcommittee wishes to submit as representing practise with suspension insulators the curve published by Mr. Peek in the *General Electric Review* of February, 1922. Attention is called to the difference in factor of safety between pin and sus-

pension insulators, particularly at operating voltages in the neighborhood of 60 kv.

Routine Test Specifications

The Subcommittee has given consideration to specifications covering routine factory tests on both pin and suspension units and suggests the following forms.

The Subcommittee does not take the position that these are necessarily the only tests which should be considered or, on the other hand, that all of the tests outlined must be made, but leaves this to the judgment of the Purchaser.

The Subcommittee believes, however, that if the tests are called for, they should be made as specified.

Tests on Pin Type Insulators

Preliminary Test. Before assembly, all shells shall be subjected to vigorous dry flashover potential at normal frequency 25 to 60 cycles for 3 minutes. If more than 5 per cent fail, the lot[1] may be retested. If on retest more than 3 per cent fail, the lot[1] shall be rejected.

Final Test. After assembly, the insulators shall be subjected to dry flashover test for two minutes. Voltages shall be such that insulators shall flashover occasionally. Insulators failing under this test shall be rejected.

Tests on Cemented Type of Suspension Insulators

Preliminary Tests. Before assembly, all shells shall be subjected to vigorous dry flashover potential at normal frequency 25 to 60 cycles for 5 minutes.

If any shell fails during the fourth or fifth minute of the test, the test shall be continued until no shell fails during the last two minutes of test. The excess time is based on the testing of quantities up to 100 at one time. For quantities greater than 100, the excess time after the last failure may be less than two months by agreement between manufacturer and Purchaser. If more than 5 per cent fails the lot[2] may be retested. If on retesting more than 3 per cent fails the lot[2] shall be rejected.

After assembly all units shall be subjected to flashover test at normal frequency 25 to 60 cycles for three minutes. Voltages shall be such that insulators shall flashover occasionally. All units failing under this test shall be rejected.

Mechanical Test. Not more than seven days after cementing all units shall withstand for three seconds without sign of distress a mechanical pull in line with the axis of the insulator amounting to approximately 40 per cent of the rated ultimate strength. This test shall be given before the final electrical test.

1. Note: In all cases where the term "lot" is used, it should be defined as including only the number of units on the testing pan at one time.

2. Note: In all cases where the term "lot" is used, it should be defined as including only the number of units on the testing pan at one time.

Puncture Test (For Pin and Suspension Units). Puncture voltage test shall be made on units which have passed the final routine flashover test. Rejection of units for puncture shall be based on the "Average Variation" in puncture voltage determined, as follows:

Definition of "Average Variation" in Puncture Under Oil Tests

For this test purchaser will select from units offered for final inspection not more than ½ of 1 per cent of the total quantity and not less than 3 units.

$V_1, V_2, V_3, \ldots V_n$ = individual puncture values.

V = average puncture voltage.

$V = (V_1 + V_2 + V_3 \ldots + V_n)/n$

Let

$a_1 = V - V_1 \quad a_2 = V - V_2 \quad a_3 = V - V_3 \quad a_n = V - V_n$

Consider all the values of a as positive, that is, neglect the signs.

Let a = average variation

A = average variation, per cent.

Then

$a = (a_1 + a_2 + a_3 \ldots + a_n)/n$

$A = 100\, a/V$

Example:

Five insulators punctured at; 150, 135, 145, 138, 142 kv. respectively.

$V = (150 + 135 + 145 + 138 + 142)/5 = 142$

$a = (8 + 7 + 3 + 4 + 0)/5 = 4.5$

$A = 100 \times 4.5/142 = 3.17$ per cent

If "Average Variation," A, exceeds 10 per cent, the entire quantity shall be rejected, or at the manufacturer's option and expense an additional 2 per cent may be tested. If the "Average Variation," a, obtained from this second test only exceeds 10 per cent, the entire quantity shall be rejected.

Ultimate Mechanical Strength (Suspension units only). Not more than 7 days after cementing, ten units shall be selected for this test from each 1,000 ordered. If any fail at less than 85 per cent of the manufacturer's rated ultimate strength, an additional 20 units shall be tested at the manufacturer's expense. If none fail at 85 per cent of manufacturer's rating, the lot shall be accepted and if any fail, rejected.

Expense of Material for Tests. As far as practicable, tests shall be made upon units which have some defect and are not salable but are otherwise acceptable to the inspector for the test in question. In addition, Purchasers shall be allowed to test commercial insulators to destruction up to ½ of 1 per cent of the total number ordered. If additional units are desired for such tests, they shall be paid for by the purchaser.

We believe that the above completes the work assigned to the subcommittee. In the course of its discussions, two questions came up which it appear should be subjected to further laboratory study and the subcommittee suggests these for your consideration.

1st. The relative effect of 25- and 60-cycle tests.

2nd. It is believed that the mechanical strength

of a string of insulators decreases with time. The maount of this should be ascertained.

The subcommittee believes that the material included in the above report should be treated in the same way as the design test specifications previously reported on, that is, it should be published and subjected to criticism, so that it may be revised before any definite action is taken. It would be highly desirable, if possible, to have this material presented at the April meeting of the Institute in Pittsburgh, at which time the design test specifications are scheduled for discussion.

The subcommittee would like the permission of the Standards Committee to arrange for this, if possible.

Respectfully submitted,

P. JUNKERSFELD

Chairman, Insulator Subcommittee
of the Standards Committee, A. I. E. E.

The Production of Porcelain for Electrical Insulation—IV

BY FRANK H. RIDDLE

Champion Porcelain Company
Jeffery-Dewitt Insulator Company

Review of the Subject.—*The three previous articles have been devoted to giving a brief description of the theoretical points involved in the development of porcelain. The following articles will briefly describe the actual manufacturing methods and the application of the theoretical points.*

Recent developments in plant management and control have been applied to porcelain manufacture in the same manner as they have to other industries, and the old rule of thumb and trade secret methods are fast disappearing.

Ample storage room for raw materials is necessary for a uniformly high grade product can only be made when there is ample time to test the raw materials prior to using them, and to permit of the rejection of inferior materials when necessary without causing any delays in production.

Accurate methods of weighing the various raw materials to form the final raw body are necessary. Care must be used in determining the per cent of moisture in each raw material so as to compound the body on a dry weight basis.

The old method of preparing the body by mixing or blunging, with the idea of merely suspending the raw materials in water without regard for grain size is to be avoided. Many potters are now grinding the materials in pebble mills and working to definite grain sizes.

The ground body is passed over a magnetic separator to remove magnetic iron, then passed through a fine mesh (120 meshes to the lineal inch) lawn and filter pressed to eliminate excess water, and thus put the ingredients in a workable condition (approximately 22 per cent water). The materials for porcelain can also be stored easily while in this condition. By storage the plasticity is not only increased, but time is available in which to run actual tests on the materials before releasing them for production.

The moisture content in filter press cakes is not uniform throughout the cross-section of the cakes. A greater degree of homogeneity is produced by pugging the body after filter pressing. A pug mill develops uniformity to a high degree when properly handled. Several methods of shaping the body into final form require different methods of preparation. Each of these will be described in later issues.

CONTENTS

Process of Manufacture

Modern efficiency methods and ceramic research have brought about changes in plant design in the manufacture of porcelain just as similar studies in other industries have made marked improvements in their methods. Where it has been impossible to make changes in older plants on account of such conditions as lack of space or other unavoidable difficulties it has still been possible to install modern equipment. As a result many plants have been able to improve their methods in one or more respects.

In the early days potters were very secretive and their processes and particularly their formulas were guarded with great care, the knowledge being handed down from father to son. This condition still exists to more or less extent in some branches of the potting industry. Those who have been slow to give information to others however have been slow to learn from others and have not been prone to adopt methods which are more modern and based on sound engineering principles. Continued practise along the old lines can, of course, result in only one end.

In describing the methods of manufacture it will be necessary to repeat, in some instances, part of the work previously described, particularly when discussing raw materials, body mixtures and the behavior of the bodies and glazes during burning. This will only be done in such cases as will make it possible to describe the processes more thoroughly.

Raw Material Storage

The supply of raw materials an insulator plant should carry in stock should be governed not only by production and the time necessary to receive new shipments but also by the time it requires to test new materials upon receipt, and before they are certified for use in

production. The stock should also be large enough, so that if any cars of new materials are rejected on account of quality there is still sufficient stock to permit production to go on undisturbed. These conditions being considered, it is necessary that the testing methods be such that new materials can be checked up without delay. It is obvious that great care should be used in selecting the sources from which the raw materials are purchased, taking into consideration not only the integrity of the dealer, but also the quality uniformity and size of the deposit from which the material is secured.

Most potters secure their materials from several sources and proportion the different ones, in compounding their bodies and glazes, so that some material is used from each source, thus eliminating somewhat a chance for serious trouble in case one of the sources supplies an inferior grade of material.

Ball clays hold moisture very tenaciously and hence are usually received in a moist state. It is well to keep them in this state, in fact some potters keep clays of this type well dampened not only to prevent loss of plasticity but also to make it possible for the material which is received in rather large lumps to be blunged up or put in suspension more easily in the preparation of the body.

The weighing of the bodies and glazes is an operation where considerable care should be used and some method arranged for checking. The most satisfactory method is by use of charging scales in which the weights are set and locked by the foreman thus obviating the necessity of the operator's knowing the quantities used and also the possibility of errors caused by incorrect weighing.

In weighing out a batch it is always necessary to determine the per cent of moisture in each raw material and allow for same. The moisture content in flint and feldspar is usually under two or three per cent, however china clay may run as high a content as ten or twelve per cent and ball clay even higher.

With a body mixture containing 50 per cent of clay with a moisture content of 15 per cent it would mean that there would be a shortage of 7½ per cent of clay in the body if the moisture content was not allowed for. This is assuming that the remaining 50 per cent of the body batch was dry. This is likely to be so as the remainder of the batch would be flint or feldspar, both of which have a low per cent of moisture. These exact conditions are not unusual in some general ware factories today.

Preparation of the Body (The Mixed Ingredients)

The usual method of preparing or washing the body, as the raw material mixture is called, is to blunge it. A blunger (Fig. 15) is a large tank equipped with revolving arms. The batch, together with a proper amount of water, is placed in the blunger and churned until the raw materials are disintregated and suspended in the water. This method of preparation, although quite commonly used, is inferior in many respects to grinding or even mixing in pebble mills. The blunging process simply disintegrates the lumps of raw materials and suspends the particles in water. This is not so serious in the case of the clays, particularly the ball clays as they are naturally very fine, however the flint and feldspar are ground rock and the manufacturer who blunges is entirely dependent for grain size upon the miller. If there is any variation in grain size in the miller's product this same variation will be in the blunged body. The chance for variation here depends not only upon the care the miller uses but also upon how carefully the manufacturer checks the raw materials received. It is common practise for the miller to supply 120 or 140 mesh product and it has been found and will be shown later that 140 mesh product does not produce so good a porcelain insulator product as finer material does. By 140 mesh product is meant a product which is sufficiently fine so that all of it will pass through a lawn which has 140 openings per lineal inch, a great proportion of the material being much finer than 140. It is also important to know not only the size of the coarsest particles but also the percentage of various fines contained. This should always be considered as some millers, in using one type of grinder will get various percentages of fines where another method will produce an entirely different ratio of the various sizes.

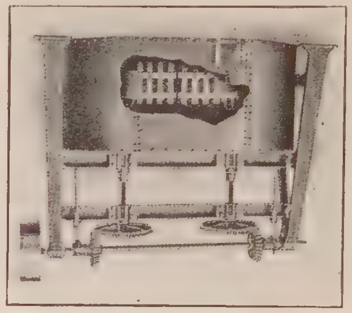


Fig 15

Blunger in which the raw materials, clay and pulverized quartz, or flint and feldspar, are thoroughly mixed with water to form a creamy liquid. This method of preparing the body results in the potter's having no opportunity for making a product of a finer grain size than his raw materials have when supplied to him.

In the grinding process pebble mills (Fig. 16) are usually employed. As the illustration shows they are cylinders supported on trunnions so as to revolve around the horizontal axis. They are lined with quartz or porcelain tile and filled about half full of small porcelain or quartz pebbles. They can be used for either dry or wet grinding, however wet grinding is usually employed in a modern pottery. If a pebble mill is not operated properly it will give a wider range of grain size and be less dependable than a blunger but where used properly it is beyond comparison. It is essential to standardize on not only the quality of the grinding parts as pebbles and lining, but also on the revolutions per minute, total time of grinding, weight, bulk and

size of pebbles, tonnage of the grinding charge and particularly upon the quantity of water. If the water content is too low the sticky mass will cement the pebbles together and nothing will be accomplished,

Fig. 16

A battery of 5-ft. diameter pebble mills used for final grinding of the previously weighed out body mixture. These mills revolve at approximately 15 rev. per min.; each carries 5 tons of porcelain pebbles and all conditions are accurately calibrated to insure not only fine but uniformly fine grinding, thus eliminating the possibility of lack of uniformity due to not securing properly ground raw materials from the miller. Two tons of body are ground per charge.

while if too much water is used the slip will be so thin that the pebbles will wash around in the mass and accomplish very little grinding. With just sufficient water to form a thick slip each pebble will be coated with a layer of slip which will adhere to the pebble as

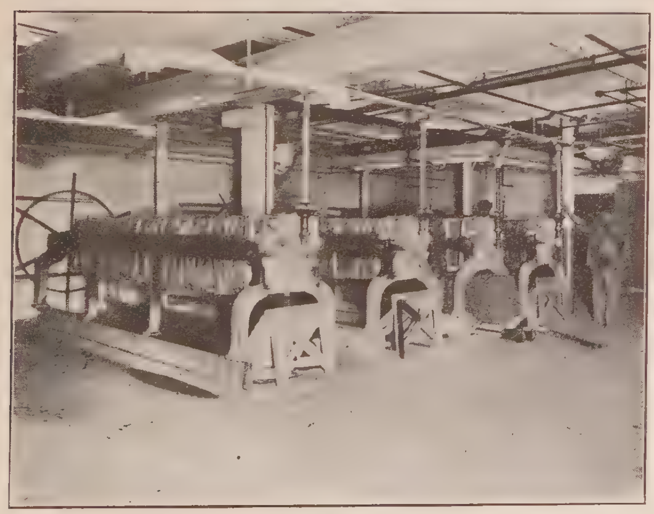


Fig. 17

Filter presses in which the water is forced out of the body which has just been ground and lawned. This body or slip, as it is known in the liquid state, is about the consistency of cream until filtered at which stage sufficient water has been removed to make the body stiff enough to model or form into shape.

it rises up out of the slip, and rolls back down over other pebbles into the slip, as the ball mill revolves.

Where a body is made up of coarse grained non-plastics such as flint and feldspar, and fine grained clays such as English ball and China clays it may be necessary to grind the non-plastics and put the clays into the mill only near the completion of the operation and then just long enough for a thorough mixing. Where this is done additional water has to be added when the clay is added. It is also necessary, where the non plastics or grinding charge is rather coarse, to float it with a small amount of plastic material to prevent its settling and caking. The amount of water to add to a charge depends not only upon the character of the raw material but also upon the amount of water it already contains as natural moisture. After the slip is made it is passed over a magnetic separator and through a lawn. The fineness of the meshes of the lawn depends upon the quality of slip the potter desires. Usually a silk bolting cloth of 120 mesh is used. Obviously the lawn is only used to eliminate coarser particles of foreign material. This is extremely important in insulator porcelain.

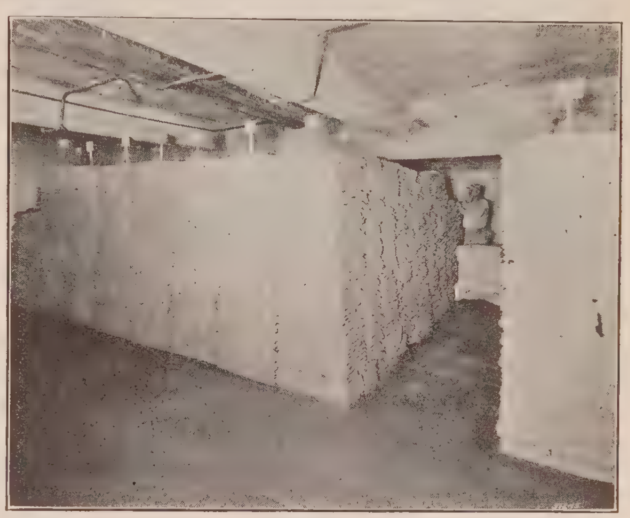


Fig. 18

Storage and aging cellar in which the filter pressed body is held until used for production. It is customary in some plants not to release any of the body for production until it has been carefully tested and then to release it in batch lots which are kept segregated throughout the process of production, giving the manufacturer a close check upon his manufacturing processes.

Recently the writer's attention was called to a manufacturer who was importing English clays in drums in order to prevent contamination. This would unquestionably facilitate handling, but it is doubtful if the expense was warranted if the proper equipment was employed in the body preparation. Punctures can be caused in porcelain if hairs or threads from sacks are in the body when it is formed as these burn out later and leave thread-like holes. If the proper lawn is used in screening the slip and it is properly inspected this trouble should not occur if the foreign material is incorporated before lawning, however, if the materials get into the body after lawning, troubles can occur. This is one reason why care should be used in the selection of proper quality filter bags.

The filtering off of part of the water to reduce the water content in the slip to bring it to proper stiffness for plastic forming is almost universally done in a leaf type periodic filter press (Fig. 18). These presses usually produce seventy-two leaves of body 24 by 24 by

$1\frac{1}{4}$ in. After filter pressing the body will contain about 22 per cent of water. The slip is forced through a pipe which enters the press at the end and passes on filling the first narrow chamber then through into the next chamber, etc. When all the chambers are full the hydraulic pressure starts to rise and the water is forced from the particles of body through the canvas linings of the chambers and out through small ports at the bottom of the grooved steel partitions between the chambers. The pressure used, sizes of meshes of the weave of the canvas, speed of pumping and several other variables all effect the quality of the finished insulator. If the slip forced into the filter press is too thin it will cause a separation which will result in a lack of uniformity in the cross-section of the cake.

FIG. 19
Pugging or thoroughly mixing filter pressed cakes after they have been properly aged. This not only eliminates considerable air from the body, but also makes the mixture of body and water very uniform, thus eliminated drying cracks and strains at further stages in production.

The usual method of applying pressure to the slip to force it into the presses is to use a plunger pump. Obviously the plunger has to be lubricated and as a result some oil enters the filter press with the slip. A more refined pump is the diaphragm pump which prevents grease from contaminating the slip. Both these methods produce a pulsation which tends to some extent to fill up the meshes of the filter cloths and retard the flow of the water. A third method is the use of compressed air. The air is pumped into a tank containing slip and forces the slip into the press. This produces a uniform pressure and keeps the slip free from contamination. It not only makes it possible to filter more rapidly but at a lower pressure and results in a cake of greater uniformity.

Some plastic process plants form the body immediately after filter pressing it, pugging it or mixing it. However, it is considered good practise to store or age the body for a period before using it. This aging is usually done in a close damp room or cellar where the body cannot dry out. (Fig. 18). There are several reasons for aging; the principal one being that an aged body will not only form better but yield a higher percentage of first quality ware. Greater plasticity is developed. This is particularly useful in high grade wares where it is desirable to use just as white burning materials as possible. White burning clays are usually short or non-plastic while the ball-clays although plastic do not burn white and their content must be kept as low as possible.

Several theories have been advanced regarding the causes of the development of plasticity during aging and its effect upon the final product. Additions of very small amounts of acids have been known to accelerate the effect of aging. Bacterial growth is also supposed to assist. The writer had experience during the war at the Bureau of Standards with an extremely short kaolin body from which special porcelain propellors were made for stirring optical glass experimentally. Two lots of bodies were used, one being six months old and the other newly made. The aged body worked very well while the new body could not be shaped at all.

One big advantage of storing body at this stage is that it gives time to experiment with preliminary lots through the several processes to see if the body is satisfactory. This is not essential in all grades of ware but in some high grade wares and where the body is extremely sensitive it is invaluable.

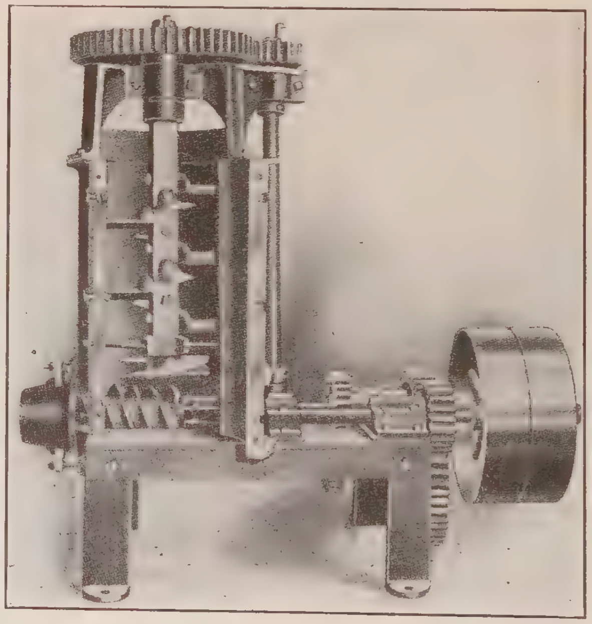


FIG. 20
Interior view of pug mill.

PUGGING

Filter press cakes whether taken directly from the press or aged, require a thorough mixing in order to produce better homogeneity. This is done in a pug mill, Figs. 19 and 20, which not only thoroughly mixes the mass but also tends to develop plasticity as well as assisting in eliminating any enclosed air. Proper pug-

ging necessitates careful study as each body works differently and requires special attention.

As shown in the illustration, a pug mill is a barrel shaped machine which has a series of knives or propellors revolving in it around a central shaft, the knives having a pitch to them which will keep forcing the material down through the barrel from the top where it is fed in. This forcing down and packing as mentioned above, improves the quality of the body.

At the bottom of the barrel is a horizontal shaft also equipped with knives which forces the body sideways out through a port or die in the side of the pug mill. Sometimes pieces are shaped by the die and simply cut to length. If this is done it is necessary to have the conditions as near right as possible. Two sources of trouble arise in a pug mill known as auger lamination and die lamination. The first is caused by the knives or propellors polishing the clay so that it does not properly cohere when forced through the die. This gives an effect similar in a way to the spirals on a stick of candy. The second trouble is die friction. A column of clay like other liquid or semi-liquid masses flow fastest where there is the least friction. This will sometimes cause laminations or slips in the mass which will not heal or adhere and the result is that these slippage cracks will remain in the mass clear through the process resulting in a damaged porcelain, and the defect in most cases being so hidden that it is not noticeable until severely tested either in final inspection or in service.

Discussion at Midwinter Convention

DISCUSSION ON "MACHINE SWITCHING TELEPHONE SYSTEM FOR LARGE METROPOLITAN AREAS*"

Craft, Morehouse and Charlesworth

New York, N. Y., February 15, 1923

Frank B. Jewett: There is very little that I can add to what Mr. Morehouse has outlined to you in the paper except to point out one or two collateral features of this very substantial trend which we are experiencing toward the increased use of machinery to perform functions which ordinarily require human intelligence.

My principal contact with this machine switching problem has been on the engineering and manufacturing side, and the thing that has struck me most forcibly is the fact that we appear to be trying to the best of our ability to make a mechanical human being.

The register to which Mr. Morehouse refers embodies I believe, the nearest approach to human intelligence that has yet been invested in a mechanism. It has some truly remarkable characteristics which heretofore have been associated in our minds largely with the characteristics of human beings.

The attempt to go farther and farther in the direction of making inanimate material take the place of animate human beings and perform their functions not only today but tomorrow and the next day and to perform them economically, has imposed an increasing necessity not only for greater accuracy and care in design but also greater care in the selection of the materials which we employ. In turn these refinements are increasing the pressure on us to enquire deeper and deeper into the fundamental characteristics of materials and into the ultimate construction of matter, in order that we may put into the machine those things that will best serve the purpose for which they are designed and serve them for an indefinite time, and so far as possible be things which will give us a preliminary warning of failure.

If we have a human being in a chain of things which require a human being to be present, and that human being becomes defective, when we replace him by another we replace many functions. When we put the characteristics of a human being into machinery and the machinery becomes defective, it is not the simple process of substituting one biped for another and so replacing many functions, but we have to do it more or less piecemeal. The result is that so far as possible we must obviate the possibility of failures which, if they occur, will greatly complicate and deteriorate our service and at the same time give us no adequate opportunities for immediate replacement. The telephone service of today is a thing which will stand for no material degradation and will tolerate no material delays in replacing parts or defective arrangements.

There is another point which, in passing, may be of interest. In summarizing his paper, Mr. Morehouse has pointed out that the net result ultimately would be a reduced requirement for operators, not necessarily a smaller total than we now have but a smaller total than we might have required had we gone along on some other basis. This does not mean that the total amount of human labor involved is decreased to the same extent that we can reduce the number of operators, because to a certain extent what we are doing by this process of substituting machines for human beings in the making of telephone connections is to transfer human labor from one place to another. In other words, to a certain extent we are transferring the human labor of the operator to the human labor of the factory because the machine switching mechanism increases the total amount of manufacturing effort that is required.

The factor just referred to is something we must take into account when considering the economics of the machine switching problem. The net result of machine switching is likely to be a conservation of human labor in preparing for and in providing telephone service, but insofar as we transfer human labor to the factory to make machines which are more accurate and complicated than the machines of a simpler structure, we have increased the problems of our manufacturing department beyond what they now are.

Bancroft Gherardi: A natural question always arising in the case of a new development is—who did it? People unfamiliar with development work of this kind sometimes think that that question can be answered by naming one or two, or perhaps half a dozen people. The reverse is the fact in this case. This machine switching system which Mr. Morehouse and the other authors of the paper have so ably described, is literally the result of the combined work of thousands of people, of whom I will venture to guess more than 100 are in this room.

Like most successful developments in many respects this is an evolution rather than a revolution. It builds to a considerable extent on what preceded it.

Looking at the pictures of the machine switching board, we note that it does not look much like the manual common battery switchboard; and yet I would like to point out a few of the elements of the common battery switchboard that will be found equally important in the machine switching board.

It employs, of course, the metallic circuit and the twisted pair. It employs the standard, three-wire switchboard arrangement, by which there are two-wire talking wires and a third wire within

*A. I. E. E. Journal 1923, Vol. XLII, April, p. 320.

the central office, used for various signaling purposes. It employs the common battery talking and signaling system; in fact, if you were to take the circuits of a machine switching office and separate from the signaling circuits the talking circuit itself with the battery supply arrangements, you would find it to be identical with the talking circuit of the standard common battery switchboard. You would also find that the line relay and the supervisory relay were present in the machine switching circuits in the same general way, but performing different detailed functions from those in the manual system. I could go on with many other points of this kind but I think I have given you enough to illustrate what I have in mind.

You may be interested in the extent of the application of this system. There have been two of the machine switching offices of the kind described, already placed in service in Omaha. One is in service in Kansas City, and a small one in Newark, also one in Paterson, New Jersey. Three have already been placed in service in New York, and many others are under way in New York and elsewhere.

There is one more point which is of considerable importance in connection with this development. Some of you know perhaps that the lawyers recognize it as a principle of cross-examination that you should never ask a question of a witness unless you already know what the answer will be, or you don't care.

Now, we have somewhat the same situation in experimental work that involves the public. We do not wish, when it is possible to avoid it, to do any experimental work involving the public, unless we already know it is going to come out all right, or we don't care. Now, we always care, so the alternative is that we must practically carry on our development work so that we know before we try to experiment, so far as it is humanly possible to know, that the result will come out as we hope and anticipate.

That has been a difficult matter in connection with this machine switching system, and yet the result has been accomplished. In one way or another, we have been able during the progress of the experimental work, when it got beyond the point that the answer could be obtained in the laboratories, to try out element by element of the system in service, in such a way as to get the answer we wanted, and at the same time, take no chances on the service that was being rendered in the meanwhile.

The result was that when the first complete office went in service in Omaha, we felt a moral certainty that all would go well and everything did go well. In fact, the newspaper and public comments on the following day were practically unanimously favorable.

Fred L. Baer: It has been my pleasure, for the past twenty years, to be connected intimately with the operation and promotion of automatic switching equipment of the step by step type. The function of telephone switching equipment of any kind is essentially that of connecting together subscribers in different parts of an area and then affording them facilities for easy conversation. As Mr. Gherardi has pointed out, in a machine switching system, after the connection has once been set up, the facilities for conversation are virtually the same as in manual practise, with which most of you are familiar.

In the early years our principal endeavor in designing and producing automatic switching equipment was to take care of the large percentage of normal calls such as local city calls. The number of toll calls formed only a small percentage of the total traffic and were handled in each case in the most expedient manner. Later, the general advancement of the art and the more exacting requirements of the telephone using public were met by a corresponding development in the art of automatic switching, so that it can now be safely said that telephone requirements of every nature can be satisfactorily met with machine switching equipment.

The problem that now confronts us is the one usually experienced in the development of any art, *i. e.* having accomplished certain desired results, to find ways and means of effecting economies so that these results may be obtained with the lowest possible expenditure.

Regardless of the question of cost there are some cases where automatic switching equipment is useful in meeting certain definite conditions, for instance, where climatic conditions make the maintenance of an adequate operating staff almost prohibitive, or where there is a polyglot population and it becomes almost impossible to maintain an operating staff sufficiently conversant with the various languages used locally to give satisfactory service.

One of the questions that Mr. Gherardi touched upon, that of the public attitude, was very interesting to me for the reason that I had always made it a point to learn the public reaction to the service, wherever possible. I believe we, in the telephone business, have been unduly apprehensive. While the telephone business is our principal activity, it is only an incidental thing to the public. If machine switching service meets the public requirements in a more satisfactory manner than has previously been done, the reaction is favorable. If it does not, the reaction will be unfavorable. Fortunately, however, I know of no case where this reaction has been unfavorable because of the fact that the service given by machine switching telephone systems is, from many angles, superior to service given manually.

F. J. Chesterman: We in Philadelphia have very similar problems in a smaller way, to the New York problems, and we are engaged at the present moment in preparing for the Sherwood cut-over.

I think we should each of us bear in mind that in introducing developments into a telephone system such as we have in New York and in Philadelphia, it must be done in such a way as not to interfere with the orderly operation of the system. In the plan which has been adopted, with the exception of the subscriber who is directly involved and who has a dial on his own telephone, there is no change in the method of making a telephone call. In other words, whether you are calling a manual or a machine switching subscriber, the procedure is identical in either case. This seems to be the point which has bothered the layman more than any other, and in talking with a public service Commissioner recently, he had the impression that two telephones were required at the subscribers' premises, one for calling machine switching subscribers, and one for calling manual subscribers. If this were true, each subscriber would have to know the type of service which every other subscriber had, and this, in a city such as Philadelphia or Pittsburgh, is, of course, impracticable; so that one of the prime requisites of a machine switching system, which necessarily must be installed a unit at a time, is that each machine switching telephone must be able to communicate, as in the past, with the whole telephone system.

There is another requirement of machine switching, which Mr. Morehouse dwelt upon, and that is, it must be able to handle all classes of calls; not only flat and message rate, but also coin boxes. It must be able to handle calls to toll points, calls for information, and a thousand different types of calls which are encountered in the operation of a complete telephone system. Not only must the machine switching system fulfill these requirements, but it must be such a system that its use will not entail material changes in the method of operating the existing system; I refer now to the manual offices with which the machine switching system must co-ordinate.

It would be obviously a very material problem to train the manual operators to handle connections from machine switching offices in a totally dissimilar manner from that in which they handle calls from other manual offices; and Mr. Morehouse pointed out very distinctly, I think, the pronounced similarity in the method of handling calls from the two types of offices.

In a similar manner, calls from a manual to a machine switching office are handled in practically the same way that calls from

one manual office to another manual office are handled. By this means, the effect of machine switching operation is localized practically to the particular unit that we are installing, and does not interfere or change or modify in any material sense the operation of the telephone system as a whole.

I think therefore the machine switching system as described, fulfills all of the main essential requirements that we have been reviewing just now, but in addition to that, it is meeting all of the requirements for a complete telephone system.

E. B. Craft: I am simply going to touch upon some of the problems, that we have had to deal with in connection with this development, pertaining particularly to the mechanical and electrical design of the mechanism itself.

The necessity for large groups of trunks in Metropolitan areas has brought forth the necessity for large-sized selectors, and the panel mechanism which has been illustrated and described, embodies a number of features mechanically that are of general interest, not only to telephone specialists, but to any engineer who has to do with the design and construction of machinery.

Let us consider for a moment just what this mechanism has to do. We have in the selector rod that goes over the face of these panels, a piece of apparatus which is about seven feet long and weighs about a pound and a half. It must be so arranged that it can travel over the face of the terminals at the rate of possibly 60 terminals per second. As these terminals are 1-8 of an inch apart, you can gather some idea of the precision with which this rather substantial mass of material must be controlled. Of course it is not a new thing to select groups of terminals by machinery. The outstanding feature of this mechanism, however, is, that we are dealing with a much larger mass of material which must be controlled, and with much greater distance over which we must travel. This large size precludes operation by the usual forms of electro magnetic devices, and it has been necessary therefore to use continuously-applied power means. This is the reason for using the power drive.

Now, in the introduction of this power drive, we are getting into some new fields in that we must by all means insure continuity of operation. This power drive mechanism, both motors and friction roll drives which are associated with each other, must operate every hour in the day, every day in the week, and every week in the year. Such seemingly simple problems as lubrication have given a great deal of trouble. These mechanisms as I say, must operate continually, and there are real and fundamental problems of lubrication which have entered into the design of them. On the other hand, practically all parts of the mechanism, outside of the power drive itself, must operate without lubrication. Because of the lightness of the construction of some of the smaller fast-moving parts, the application of lubricating materials will oftentimes interfere with their operation, so that we have many problems where the design and the materials must be such that parts will operate for long continued periods of time without any lubrication whatever.

In this connection, it may be interesting to refer to the motor which is used to drive this selective mechanism. In order to insure this continuity of operation, there has been provided a so-called duplex motor for the operation of the lifting drives. This motor is so arranged that it normally operates directly from the usual public service supply, either alternating or direct current. In case of failure of this power supply, however, the motor is so arranged, that without any outside manipulation whatever, it automatically switches to the power leads from a storage battery located in the building, so that its continuous operation is insured. The throw-over from the main source of supply to this emergency source, is such that the motor will not stop and the mechanism is maintained in continuous operation, even though the primary source of power supply is removed.

The terminal bank which is illustrated in the paper and shown on the screen, involved some mechanical problems a little bit out of the ordinary. This rigid structure is about 39 inches long and 15 inches high, made up of 300 strips of metal, with an equal number of insulating strips between them. This whole group of parts must be so assembled that, in its finished state, these terminals are properly centered within dimensional limits of 85/10,000 of an inch. This is done to provide as wide limits as possible in other portions of the mechanism, particularly in the moving parts. Therefore, in the fixed portions, this great precision is adhered to, to reduce to a minimum other adjustments that may have to be made.

Furthermore, these parts must be insulated from each other to withstand unusually high potentials that may occasionally be applied and in order to insure this they are tested with a potential of 500 volts. The proper insulation resistance between the parts must be maintained at a proper point at all times.

Now, in a full-sized central office, such as we have been describing, there may be as many as 4000 of these selecting mechanisms, 4000 of these rods, and in the ultimate plan for the Metropolitan area, it is expected there may be as many as 300 offices, so that we may have over a million of these devices that may be involved in the giving of service in an area such as the Metropolitan district. Each one of these selecting mechanisms must be constructed with sufficient precision that it may be removed, and a new one introduced, or so that any part of the mechanism can be replaced, without recourse to machinery for making the replacement. This presents a problem of interchangeable manufacture which is in a class by itself.

Now, we go to the dial. The only intelligence that is transmitted from the substation in this machine switching system to control the central office mechanism is through the agency of electrical impulses. Therefore, it goes without saying, that these must be very accurately controlled.

The dial which has been described to you is arranged to transmit pulses at the rate of ten per second, with a variation of plus or minus one pulse. There must be a definite relation between the period of make and break of the electric circuit so that this little device located at the substation, which is used to transmit electrical impulses, has a period of make, held between the limits of twenty-five-thousandths of a second, and fifty-thousandths of a second, and a period of break between forty-five-thousandths of a second, and one hundred thousandths of a second. What we really have here at the substation, subject to all the rough usage that devices of this sort usually receive, is a real instrument of precision.

H. P. Charlesworth: There is one matter that comes to mind which is of considerable importance from the subscriber's standpoint and which may be of interest here.

Mr. Chesterman has mentioned that one of the fundamental requirements that a satisfactory machine switching system must meet is that any subscriber shall not be required to perform essentially different operations in reaching different switchboard systems from the same telephone. In other words, the machine switching subscriber must not have to differentiate between a manual telephone and a machine switching telephone and neither must the manual subscriber have to similarly differentiate on his part.

This naturally brings us immediately to the telephone numbering system which is referred to in the paper and perhaps just one word regarding it may be of considerable interest. The automatic system receives a call, of course, from the subscriber through the medium of the dial. The call must come in as a suitable number of electrical impulses. We would, therefore, naturally think of adopting for machine switching subscribers, telephone numbers consisting entirely of numerals, and this plan is in fact followed in small exchanges. However, in the case of New York, for example, this would mean seven numerals, three to control the selection of the desired office and four for the number itself. A letter would also have to be added if a manual party line station was being called.

Such numbers would be very difficult for both the subscriber

and operators to use. Furthermore, it is obvious that it would be impracticable, in a large city, to change the form of listing of all the existing manual telephone numbers coincident with the introduction of the first machine switching office. On the other hand, it would also be undesirable to list, in the directory, machine switching subscribers entirely in numerals and manual subscribers in central office names and numerals. It will be seen, therefore, that the subscriber's numbering system to be employed in machine switching operation is an extremely important matter and in fact, for a time presented one of the most difficult problems in connection with large city operation. The solution when found, however, was extremely simple.

You will note from the photographs in the paper that by putting letters on the dial, the subscriber in dialing a letter would, in effect, be dialing a number. For example, in dialing PEN 4256, the subscriber is unconsciously dialing 736, 4256, or in other words, just what the machinery requires to complete the call. Obviously then, by simply capitalizing the first three letters of the office name and selecting satisfactory office names, which usually means the existing office names except where their first three letters conflict, it is very simple to arrange so that the subscriber can use the same form of listing for all calls. Thus the subscriber does not have to know whether the office called is a machine switching office or a manual office which, as previously stated, is the arrangement to be desired when introducing machine switching operation in large Metropolitan areas.

DISCUSSION ON "WIND SHIELDING BETWEEN CONDUCTORS OF TELEGRAPH AND TELEPHONE LINES"*

(Howe)

New York, N. Y., February 15, 1923

F. L. Rhodes: Mr. Howe's valuable paper advances our knowledge of a subject which has occupied the attention of engineering investigators for more than three hundred years. Study of the resistance of plates to the motion of fluids against them, goes back to the time of Galileo. Sir Isaac Newton, about 1687, announced the general formula based on theoretical considerations, indicating that the pressure varies with the square of the velocity, that is, $P = K V^2$.

Since Newton's time a vast amount of experimental work has been done along two lines. (1) The verification of the second degree relation. (2) The evaluation of the constant. Some investigators have added to the second degree term a small constant and sometimes first and third power terms. Fig. 6 in in Mr. Howe's paper, indicating a slight tendency for the pressures at the higher velocities to exceed those computed from the second degree formula, is interesting in the light of this early work. It is now, however, generally agreed that the equation $P = K V^2$ is sufficiently precise for all practical purposes.

Much experimental work has been devoted to the evaluation of the constant in the Newtonian formula. Rouse and Smeaton in 1759, evolved a value for K of substantially 0.0050. The weight of Smeaton's reputation carried this coefficient into use far beyond conditions similar to those from which it was derived, it having been based chiefly upon experiments with windmills. Many subsequent investigators determined values for K, working with plates and solids having small surfaces borne by rotating arms which were whirled rapidly. The methods employed were subject to several sources of error.

Within the past half century more carefully conducted experiments have indicated that a constant of from 0.0040 to 0.0043 more nearly represents the actual relation than the Smeaton constant of 0.0050. These values apply to the pressure on plane surfaces normal to the direction of the wind. As early as 1798 Samuel Vince determined that the resistance offered by the convex front of a hemisphere was only about 0.4 of that offered by its flat base front. Subsequent experiments by Col. Duchemin and others showed that the resistance was much affected by the shape of the front surface. Duchemin made use of a coefficient of 0.6 to give the relation between the pressure on cylindrical surfaces as compared with the pressure on flat surfaces of the same diameter. At the present time a coefficient of about $\frac{5}{8}$ is generally used, and applying this to the constants given above for plane surfaces gives results of from 0.0025 to 0.0027, which are closely confirmed by Mr. Howe's experimental results for a single wire.

In considering the precision of the Newtonian formula, it should not be forgotten that, strictly speaking, corrections should be made for temperature and barometric pressure. For example, the pressure decreases about 1 per cent for each $4\frac{1}{2}$ deg. fahr. rise in temperature, and increases about 1 per cent for each 0.36 inch of barometric pressure.

Turning now to the question of shielding, Fidler, writing in 1887 on Bridge Construction, pointed out that when the wind blows upon a grating or lattice girder, the pressure on the grating or girder is somewhere between that of the entire area enclosed by its perimeter and that of the actual front surface of the bars or plates that compose it, and the pressure on a second girder in the rear of the first would usually be less than that on the first. He suggested the need of practical tests and stated that it is very probable that the amount of shelter varies somewhat with the shape and arrangement of the lattice bars, and very certain that it varies very greatly with the distance between the girders.

Quantitative results as to shielding have been conflicting. For example: Baker, in connection with the Forth Bridge Investigation between 1884 and 1890, found that if two similar disks were placed exactly in the rear of each other, but at distances apart of 1, 2, 3 and 4 diameters, the total pressure on the combination amounted respectively to 1.0; 1.4; 1.6 and 1.8 times the pressure on the front disk alone, and that the total pressure was but little if any increased by the insertion of intermediate disks. On the other hand, Thibault had found as much as 1.7 pressures at single diameter distances.

The allowance for shielding effect has apparently gradually crystallized into the use of one and one-half times the projected area of latticed structures.

It has long been known that some shielding effect occurs in the case of ice loaded wires on crossarms, and, as pointed out in Mr. Howe's paper, conservative assumptions have been made in the past to take account of this effect. It is gratifying to have available this data from actual measurements conducted on a full scale section representative of an actual wire line.

The author has called attention to a factor which is not ordinarily taken into account directly in engineering computations of wire lines, namely the inertia and the swaying of the ice loaded wires. Another factor is the swaying of the poles themselves, which sometimes, when the ground is not frozen, results in enlarging the pole hole transversely to the line, so that considerable motion of the poles and wires may result. There is also, as shown by Langley, the fact that, particularly in high winds, the air moves in a tumultuous mass, the velocity at a single fixed point sometimes jumping almost instantaneously from one extreme to the other. The variables involved in wire line engineering are many and their relations are complex. The mathematical treatment of the problems of design is of value in developing clearly the effects of changes in the various important factors involved thus acting as a guide to progress, and in smoothing out inconsistencies that would otherwise be liable to occur in the case of lines having widely different characteristics.

The final basis of the design must rest on the results of actual experience as reflected in the evaluation of the constants appearing in the mathematical relations. In this respect the author's paper contributes information of importance to all those who are interested in the design of pole lines carrying closely spaced wires.

E. C. Keenan: I am obliged to differ with Mr. Howe's conclusion that there is a shielding effect between wires, which will run from a minimum of 39 per cent on a 10-wire line to as high as 51 per cent on a 50-wire line.

*A. I. E. E. Journal 1923, Vol. XLII, January, p. 20.

On account of many failures of pole lines and wires along the railroads that I represent, which failures have seriously interfered with train operation, I have been carefully studying the question of proper strength of poles to safely carry our wires. The wind shielding effect of wires has been offered, upon several occasions, as a reason for lessening the initial strength in the pole line structure, but, after investigation and mature deliberation, we have rejected this assumption as unwarranted by such facts as are known and the experience we have had.

My principal reason for not accepting Mr. Howe's conclusion is based upon the fact that, in my judgment, the tests with the model conducted by Mr. Howe, did not represent conditions as they actually are found in the field. The model was designed to simulate a 10-foot section of an actual pole line, the wires being represented by wooden rods 1⅛ in. in diameter, so that these rods would represent a wire with a coating of ice ½ in. thick. The model, as constructed, maintains the wooden rods, or wires, on practically an even plane. While there may have been some slight irregularity, due to the warping of the rods, it seems to me that such irregularity cannot compare with the irregularity that exists in the wires as actually maintained.

In order to determine whether or not telegraph and telephone wires are maintained so that the wires of each crossarm are on practically a horizontal plane, I had measurements taken at sixteen places along the railroad on railroad wires and wires of other companies. These tests include leads carrying from three to seven arms of wires. I give below five examples. The figures give the distances in inches of each wire from an assumed horizontal datum line.

Case No. 1—*1st Crossarm*—0, 2½, 1¾, 4¼, 4½, 5, 10½, 6;
Case No. 2—*2d Crossarm*—6, 5½, 5, 3½, 6, 2, 1, 0;
Case No. 3—*3rd Crossarm*—½, 0, 2¼, 2¾, 5⅜, 7½, 6¾, 7½;
Case No. 4—*4th Crossarm*—3½, 2½, ½, 12½, 11½, 2½, 4½, 0, 1, 2½;
Case No. 5—*5th Crossarm*—5, 1½, 7½, 0, 1½, 0, 10, 6½, 9½, 12½.

At the other eleven places where tests were made, the results were similar to the first three cases, the last two cases being the worst found.

From these tests of the actual conditions in the field, it seems to me that very little shielding could result from wires that are, of necessity, maintained in such irregular positions.

While it may be said that the cases for which measurements are given, showing great irregularity in the sag of wires, do not represent average conditions, I desire to assure you that I have observed this condition on the ground, and I am satisfied that the sixteen tests represent the conditions that exist to a considerable extent.

The wires in Mr. Howe's model were non-flexible as compared with wires actually in service, and due to the shortness of the model span, the model wires, it seems, could not have been subject to such swaying motions as occur in actual practise in spans from 100 to 150 feet in length. Such swaying motions as occur in actual practise, undoubtedly cause the wires to deviate from the plane, thus exposing more surface to wind pressure.

In actual practise, in addition to the swaying effect, there is vibration effect, the wires doing what is commonly known in the field as "dancing," or vibrating up and down. Under these conditions the wires are very far from being on the same plane and, therefore, afford little, if any, shielding.

The supporting structure in the model does not simulate a pole support in that a pole in actual service sways considerably and, consequently, there is a general swaying effect of both poles and wires caused by gusts of wind.

The model used by Mr. Howe does not represent the actual condition of a pole line constructed on *curves* where the poles are inclined from the vertical position, and the crossarms, consequently, are not horizontal, so that the wires are not on a horizontal plane.

The above conditions seem to me to be most important, as they indicate wide variations as encountered in practise from those of the model.

In the second sentence of the first paragraph of Mr. Howe's paper, the statement is made that some observation indicates that the pressure of the wind on lines carrying many wires, is not as great as the calculated pressure on one wire multiplied by the number of wires on the line, from which the conclusion is drawn that the reason the lines did not fail was due to the shielding effect of one conductor upon another. This, it seems to me, is a supposition, and after thoroughly investigating, it might be found that the apparent greater strength of the line was due to the conditions that were not as severe as anticipated, rather than to the shielding effect.

In the last paragraph of the first column, attention is called by Mr. Howe to the fact that the tests were made in the Jersey meadows on account of the flat and open nature of the land, permitting a free sweep of the wind, unobstructed by anything that might cause unusually heavy currents, the nearest buildings, hills and depressions in the direction from which 90 per cent of the wind blows, being at least five miles away. In this connection I should like to call attention to the observations of Dr. Humphreys, Professor of Interior, Meteorological Physics, U. S. Weather Bureau, who says:

> "Near the surface of the earth the wind is always in a turmoil owing to friction and to obstacles of all kinds that interfere with the free flow of the lower layers of the atmosphere and thereby allow the next higher layers to plunge forward in irregular fits, swirls and gusts with all sorts of irregular velocities and in every direction. Indeed, the actual velocity of the wind near the surface of the earth often and abruptly varies from second to second by more than its full average value, and the greater the average velocity, the greater, in approximately the same ratio, are the irregularities or differences in the successive momentary velocities."

From the above, which is generally admitted by those who have studied the freakish and unusual action of the wind, it appears that actual conditions generally prevailing along telegraph and telephone rights of way, are more severe than in the flat, open country where the tests were made.

On page 32 of the report attention is called to the inaccuracies of the recording instruments. It would be interesting, if it were practicable to determine, the extent of these inaccuracies, because on page 25, second paragraph of the first column, the report leads me to think that it probably was considerable, as, apparently, no shielding was noticed at a velocity of 30 miles per hour, which is a rather high velocity; and then for the shielding to suddenly jump to 50 per cent at 50 miles per hour, leads me to believe that inaccuracies in the recording instruments which were noted, may have been considerably more than Mr. Howe thinks.

Attention is called to the fact that it has often been the practise in calculating transverse loads, to assume a shielding of 33⅓%. While this may have been done in certain instances, I do not believe that the practise has generally been followed by engineers, because there is not sufficient engineering basis for such assumption.

In the same column, second paragraph, "Accuracy of Results," attention is called to the effect of the structure itself upon the shielding. While the small steel channel supporting the wooden rods could have very little effect, it occurs to me that the frame itself, which is rather large and exposes quite a surface, would produce a very appreciable effect upon the wires. It would also seem that at high wind velocities if the frame happened to be rotated so as to be in the back of the supporting structure, considerable variation might be expected.

In conclusion I desire to say that, in my opinion, telegraph and telephone pole lines and wires should be constructed under the full, proper assumed loading of wind and ice for the territory in which they are located, with a factor of safety of, at least, two. Under these assumptions many variable factors must be taken into consideration, such as strengths of woods and wire, wind

velocities, thickness of ice-coating, etc. The prevailing engineering, fundamental principles that have so far been followed after many years' experience, indicate that no lessening of the assumptions should be permitted unless one is absolutely sure of them, which is especially true when one considers the small factor of safety employed in our telegraph and telephone pole line and wire work.

K. L. Wilkinson: The design of wood pole lines has always been more or less unsatisfactory from the standpoint of accuracy of calculations and the designer has had to make certain assumptions which were based on experience with overhead line construction and not on any scientifically proven physical factors. The transverse load on the line has been taken as a steady and uniform wind pressure acting equally on all wires and the pole surfaces. No allowance was made directly for impact, inertia, shielding, etc., but a rough allowance was made for these factors by using factors of safety for wood poles considerably lower than those usually assumed for wooden bridges, building and the like. Experience has shown this procedure to be justified because for many years it has been observed that certain wood pole lines stand up under storm conditions which, according to the theoretical design formulas, should cause the lines to fail. This has been widely observed particularly in telephone and telegraph lines with their large numbers of closely spaced wires and has been taken into account in their design.

The question of wind shielding, as applied to pole lines, has in the past been the subject of occasional controversy between engineers, not because its existence was doubted but because it had not been demonstrated and measured. Mr. Howe's paper is therefore particularly valuable to those interested in overhead lines construction, first because it proves that wind shielding is an important factor and second because it indicates the quantitative limits of this factor.

Shielding of one body by another in streams of fluid pressure has been a subject of consideration for many years and has been taken into account in the design of steel bridges and similar latticed structures. Experiments have been made from time to time in wind tunnels and these have yielded many valuable indications on this subject. In recent years it has been necessary to carefully study wind pressures in connection with the design of aircraft and this has yielded information which has indicated how currents of air moving at high velocities are broken up by objects of different sizes and shapes. All of these experiments and tests have tended to show that parallel objects in a stream of air do produce a certain shielding effect on each other and that this shielding depends upon the velocity of the stream of air and upon the ratio of the size of the objects to the distance between them.

I think it can therefore be said, without detracting in any way from the value of Mr. Howe's paper that he has not presented a new subject. He has, however, admirably demonstrated in a practical and scientific way the factor of wind shielding in telegraph and telephone lines and has established beyond reasonable doubt that this factor should be considered in the design of such lines.

P. J. Howe: The presentation by Mr. Rhodes of such various data relative to prior investigations of wind pressures constitutes, in effect, a comprehensive introduction to the writer's own paper on this subject. The close conformity existing between the fundamental principles previously established and the facts arrived at through the recent experiments goes far toward indicating that the design of wire carrying structures cannot have a proper engineering basis until some allowance is made for the shielding effect which closely spaced wires exert on each other.

Similarly, Mr. Wilkinson's statement, obviously based on the experience of a great telephone system, that wood pole lines stand up under storm conditions which, according to the theoretical design formulas, should cause the lines to fail, shows that there is some factor, such as shielding or the equivalent, that serves to lessen the effect of wind pressures on pole lines carrying closely spaced wires.

In his discussion of the subject on the other hand, Mr. Keenan disputes the conclusion that there is a shielding effect between wires. Unfortunately, his remarks give few engineering facts to support the many personal opinions that are expressed and in consequence, his discussion serves principally to indicate that the presence of shielding between wires is not agreeable to the speaker. In order, however, that the Institute records may contain both sides of the various questions which have been raised, it seems desirable to make a brief answer to at least a few of the assertions made by Mr. Keenan.

In the first place, he states that the question of proper strength of poles has been carefully studied by him on account of the many failures of pole lines and wires that have occurred along the railroads which he represents and that in view of the facts obtained from such experiences, he has rejected the assumption regarding shielding. The truth of the situation is that pole lines and wires have failed many times on account of inadequate strength or maintenance, but no facts were submitted by Mr. Keenan or have ever been obtainable by the writer to show the failure from ice and wind storm of a line which theoretically ought not to have failed. The fact that lines have failed in the past is no reason whatever why shielding may or may not exist between wires.

Frequent reference is made by the speaker to the fact that the wooden rods which represented wires in the experimental structure were practically on an even plane, whereas actual wires on a pole line occupy irregular positions and vibrate up and down during high winds; also that wires on curves depart considerably from a horizontal level, due to the fact that the poles on curves are inclined from the vertical. He further asserts that wires which are very far from being on the same plane afford little if any shielding.

Whether the plane of the wires in the experimental structure was horizontal or not really makes very little difference. According to Mr. Keenan's own quotation from Dr. Humphreys of the United States Weather Bureau, the wind near the surface of the earth is in a turmoil, full of gusts, swirls and varying velocities, and hence must be considered as blowing from all directions, inclined as well as horizontal. The investigation made by the writer was made out of doors under actual out of door conditions and the results, therefore, apply to the conditions that exist during the extreme disturbances of heavy wind storms and gales. Furthermore, not only did the normal level of the test wires vary considerably, as will appear from Fig. 1 of the paper, but when subjected to the forces of 50 to 60 mile per hour gales, these wires or rods fairly danced and oscillated, much as do the wires in actual pole lines. The implication that wires must be in the same plane in order to afford shielding has little justification, in view of the findings of these experiments.

Another point made by Mr. Keenan was that, according to actual measurement, the wires on individual cross-arms vary all the way from 0 to as much as 12½ in. from a horizontal level. These figures undoubtedly refer to very special cases of lines which are either of small importance or in need of repair. To believe that they are at all representative of actual conditions on a great railway would be a sad reflection on those who are responsible for the maintenance of the railroads' communication system. As a matter of fact, anyone who has traveled the great railroad systems of this country knows that mile after mile of the wires on the paralleling telegraph lines flash by with seldom a noticeable deviation from the uniform level of the wires carried on the various crossarms.

In commenting on the quotation from Dr. Humphreys, Mr. Keenan reaches the conclusion that conditions in the open country where the tests were made are not as severe as those along telegraph and telephone rights of way. Just why this might be so is not evident. Certainly human experience as-

sociates the highest winds with localities where the wind has a free sweep, unimpeded and unobstructed. In any event, results of the tests are applicable to either situation since the actual wind pressures and velocities were measured and the conclusions based on these measurements.

In discussing the possible sources of error in the tests, Mr. Keenan thinks that because no shielding was noticed at velocities much below 30 miles per hour, the inaccuracies in the measuring instruments may have been more than the writer thinks. The exact accuracy or inaccuracy of the tests is, of course, indeterminable, but it must be remembered that shielding from one object to another results solely from air disturbances that extend back of the first object, and that the distance which such disturbances extend depends on the size and shape of the first object and the velocity of the wind. It is not to be expected that any shielding whatever will be experienced until the wind attains a high enough velocity for the disturbance to reach from one wire to its neighbor. This limiting velocity is shown by the curves of Fig. 10 to range between 25 and 30 miles per hour for wires of the size and spacing employed in the tests. It would undoubtedly be considerably lower, however, with larger wires or closer spacing, and higher with smaller wires or wider spacing.

Another of the writer's statements which is questioned, is "that it has often been the practise in calculating transverse loads, to assume a shielding of 33⅓ per cent," Mr. Keenan stating that there is not sufficient engineering basis for such an assumption. The statement questioned said "it has often been the practise in calculating transverse loads . . . to neglect ⅓ of the number of wires carried—that is, to assume a shielding effect of 33½ per cent." This neglecting of ⅓ of the wires is prescribed not only in the National Electrical Safety Code issued in 1920 by the Bureau if Standards, but also in mandatory regulations, mostly of more recent date, that have been drawn up and put into effect by the Public Utility Commissions of various states such as Ohio, North Dakota, Wisconsin, Kansas and Oklahoma. The engineering basis for the assumption that shielding exists seems to be thoroughly established, as pointed out in the discussions of both Mr. Rhodes and Mr. Wilkinson, by the long continued practise of structural engineers in allowing a considerable reduction in the theoretical area of latticed structures exposed to wind pressures. The ratio between the separation of members and their size is often much greater in latticed towers and structures than in the experimental line used in the wind tests.

One of the final points raised by Mr. Keenan is that the structure which supported the experimental pole line would produce a very appreciable effect upon the wires. This, of course, is a possibility which is difficult to appraise. The main point to keep in mind, however, is that this effect, whatever it may have been, doubtless affected all wires and, therefore, should have exerted only slight influence on the relative pressures on the different wires and the shielding of the wires, one to another.

Mr. Keenan's remaining criticisms are for the most part either immaterial or already answered in the Paper under discussion. His final remarks relative to proper strengths and factors of safety for telegraph and telephone pole line construction have no bearing whatever on the matter of shielding and need no answer.

DISCUSSION ON "THE WAVE ANTENNA"* (Beverage, Rice and Kellogg),

New York, N. Y., February 15, 1923.

H. H. Beverage: Since the wave antenna paper was written, more quantitative measurements have been made on the effective height of the wave antenna. The measurements mentioned in the paper gave the ratio of horizontal to vertical voltage gradient as 30 per cent. This measurement was based on comparatively few observations and was not checked simultaneously against an antenna of known effective height. Furthermore, the measurements were based on vertical gradients calculated by Austin's formula, which gives values much lower than observed values at certain periods of the day.

Recently, a much more accurate quantitative method has been developed for measuring signal intensity, and many measurements have been made on the wave antenna at Belmar. In this case, the effective height of the wave antenna was determined by simultaneous observations on a vertical antenna of known effective height. Measurements made by H. H. Beverage and H. O. Peterson indicated that the average effective height of the Belmar long wave antenna was 200 meters. Since the horizontal length was 12,500 meters, the horizontal potential gradient is 1.6 per cent of the vertical potential gradient. At 11,000 meters, the effective height was somewhat greater than this average value, and at 19,000 meters the effective height was lower than the average value. These observations give the same order of magnitude as the calculations by Zenneck's formula for wave tilt.

On short wave lengths, that is, 200 to 600 meters, the horizontal gradient appears to be around 5 per cent to 6 per cent of the vertical gradient over soil of moderately low conductivity such as is found at Belmar. This increase in tilt with shorter wave length is in accordance with Zenneck's formula.

A further check on the wave tilt theory has been noted by comparing the effective height of short wave antennas over earth of high and low conductivity. These antennas were about 400 meters long, and measurements made by Peterson on 400 meters indicated that the signal strength on an antenna over moderately conducting ground was three to four times as great as on a similar antenna partly over salt water and partly over a marsh. In this case, comparisons were made directly with a local loop in order to check the field intensity in the vicinity of the wave antennas.

*A. I. E. E. Journal 1923, Vol. XLII, March, p 258.

ILLUMINATION ITEMS

By the Lighting and Illumination Committee

TEN YEARS OF VOLTAGE STANDARDIZATION

There is little in standardization as an engineering concept to appeal to the popular imagination. However, in the lighting industry, standardization has progressed to a high degree even though the average lamp consumer has never demanded standardized voltages, bases, or types of lamps. By adhering strictly to the fundamental idea of reducing to a minimum the number of standard voltages, bases, and types of lamps and yet developing a satisfactory lighting service for each field, the standardization movement has contributed materially in increasing the amount of light obtained for a given expenditure.

The figures of Table 1 show the distribution by voltage of lamps in the 100-130 volt class for the past four years. Voltage standardization has been a phase of the broad standardization movement in which, because of the diversity of interests involved, progress has required time; it has nevertheless been steady. Looking over the figures it is evident that in reducing the demand for voltages other than 110, 115, and 120, in the 100-130 volt range, we have gone a long way toward establishing one standard voltage. The table and chart are self-explanatory and need but brief comment. Voltages of 113, 114, and 116 have been added to the voltages whose percentage is less than 0.1, making a total of five voltages having a negligible demand. For

the first time the 110-volt demand shows a marked decrease. Up until this time, the 115-volt demand has been gaining at the expense of 111, 112, 113, 114, 116, and 117-volt. Although the demand for 120-volt lamps has increased slightly, the continued strong advance of the 115-volt lamp demand clearly indicates 115 volts as the one ultimate standard for regular lighting service.

TABLE 1—Distribution by Voltage of Lamp Demand of the United States

Voltage	1919	1920	1921	1922
100-109	0.6	0.5	0.4	0.4
110	**28.0**	**28.0**	**28.1**	**26.3**
111	0.2	...	...	...
112	6.7	5.0	3.1	1.3
113	1.8	1.9	1.0	...
114	1.0	0.8	0.5	...
115	**30.4**	**32.3**	**35.5**	**39.3**
116	1.0	0.8	0.5	...
117	0.8	0.4	0.1	0.1
118	2.0	1.4	0.9	0.4
119	0.1	0.1	...	...
120	**20.7**	**20.9**	**23.6**	**25.9**
121, 122, 123, 124	0.7	1.1	0.5	0.3
125	5.3	5.8	4.9	5.2
126, 127, 128, 129, 130	1.1	1.0	0.9	0.8
Total	100.0	100.0	100.0	100.0
Per cent of 110, 115, and 120	78.7	81.2	87.2	91.5

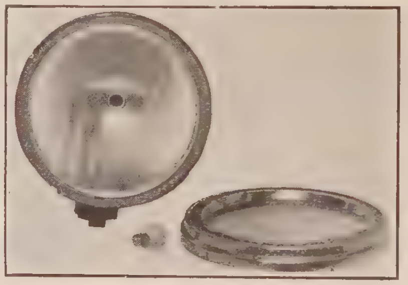
FLUTED REFLECTORS FOR AUTOMOBILE HEADLAMPS

In its simplest terms, the idea behind all good practise regulations in automotive headlighting is to concentrate the light from each lamp into a narrow beam directed straight down the road, tilt the beam so that its top is horizontal, and spread it sideways to cover the road surface. Objectionable glare is minimized by this method, since the high-intensity light is kept below the level of the approaching driver's eyes under normal driving conditions. The effectiveness of the road light depends upon the manner in which the available light is distributed over the road surface.

The ordinary method of carrying out this idea is by the use of a parabolic reflector to concentrate the light into a narrow beam and a prismatic cover glass to redirect it over the road surface. This redirection of the light is mostly in the form of a horizontal spreading or fanning-out of the beam. In addition the lens may have bending prisms to tilt the whole beam so that the top of it will be horizontal when the unmodified beam is directed straight ahead; this tilt also may be secured by tilting the headlamp. The principal advantage of tilting prisms in the cover glass lies in the fact that the light from the various parts of the reflector may be tilted and spread by varying amounts and a more desirable distribution of light obtained over the road surface.

A second method, which is just coming into commercial use for accomplishing similar results, is that of incorporating the spreading effect in the reflector itself and substituting a plain cover glass for the lens. A fluted reflector is shown in Fig. 1. The vertical flutes in the reflector spread the beam laterally. A slightly increased beam depth, which appears desirable, is obtained by the use of a hyperbolic rather than a parabolic reflector contour.

Almost all of the dissatisfaction so freely expressed by drivers as to headlighting conditions in various States having strict headlighting laws, may be traced directly to improper adjustment of headlighting equipment and to inaccuracies in the manufacture of these devices. It is fully as important that the lamp be properly focused in the reflector and the beams properly aimed with the fluted reflector as with the paraboloid and lens combination.



Fluted Reflectors for Automobile Headlamp

ILLUMINATION SCHOOLS FOR ARCHITECTS HELD IN CHICAGO

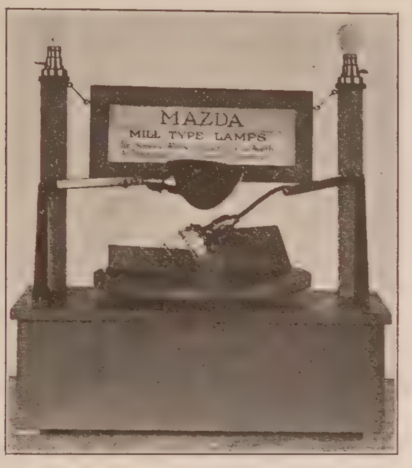
A series of lectures on illumination principles and practise was given before a group of Chicago architects January 22 to January 26 under the joint auspices of the Chicago section of the Illuminating Engineering Society and the Armour Institute of Technology. The attendance at the lectures averaged over fifty.

The relationship of illumination and architecture has grown so close with the development of modern lighting that both the illuminating engineers and the architects felt that a course in approved methods of illumination would be extremely valuable. The architectural societies therefore offered to cooperate with the Illuminating Engineering Society and the course held in Chicago was the result. Similar courses are expected to be held in New York, Boston, and Philadelphia this season. A tuition fee of $10.00 was charged for the Chicago course.

AN APPARATUS FOR DEMONSTRATING THE DURABILITY OF MILL-TYPE LAMPS

A motor driven display for demonstrating the durability of the new Mazda mill-type lamps is shown in Fig. 1. This was built especially for an exhibit at the Convention of the Iron and Steel Electrical Engineers and at the Southern Textile Exposition during the fall of 1922.

One mill-type lamp on the end of an extension cord is enclosed in a wire guard and drags on a circular table which has a number of projections on it. This table rotates at the rate of about 2000 bumps per hour and subjects the lamp to an ordeal which well illustrates its ability to withstand rough usage.



An Apparatus for Demonstrating the Durability of Mill-Type Lamps

Another lamp with a metal shade is on the end of an extension arm and is visibly subject to much vibration—another severe test of a lamp. To protect the eyes of spectators against glare, the reflector was turned to throw the light on the sign.

A NEW FIELD FOR STANDARDIZATION

The growing popularity of the convenience outlet has prompted attention on the part of manufacturers to the value of standardization. Five years ago a multitude of types of plugs and outlets were available on the market many of which were not interchangeable. Not only did the inconvenience of connecting various household appliances such as percolators, grills, etc., greatly discourage their purchase and use, but it also hampered flexibility in the use of portable lamps. Realizing the value of standardization, several of the leading manufacturers have agreed upon a type of plug and outlet which is completely interchangeable, the plugs fitting any of the outlets whether the plugs have parallel, horizontal, or T blades.

A LUMINAIRE FOR A SAFETY ISLAND OR BOULEVARD CROSSING

F. BRUEGGEMAN
Assistant Mechanical and Electrical Engineer, South Park Commissioners, Chicago

With the increasing vehicular traffic in recent years various types of signal lights for street intersections and safety islands have come into use. To distinguish these lights at a distance from ordinary street lights, red globes are used to a considerable extent. However, the base of the post is not sufficiently lighted when a red globe is used and on this account, there is danger of motorists running into it. This difficulty was overcome by the use of luminaires adopted by the South Park Commission in Chicago, and they have been used on busy intersections of Chicago boulevards with very satisfactory results.

Instead of the usual red globe a white translucent globe is used. A cluster of four lamps is arranged in this globe, the two upper lamps having red bulbs, two lower lamps having clear bulbs. A conical metallic reflector confines the light from the clear lamps to the lower part of the globe and directs it downward so as to illuminate an area surrounding the base. The conical reflector is divided into two parts to allow the globe to be slipped in place over the lamps. The reflector is placed inside the globe and the globe then placed on the holder. The shade adjusts itself on the cluster which is supported from the globe holder below.

In this case the conical reflector arrangement is used on the regular series boulevard lighting standards, the lamp cluster being replaced by a series street lamp and an inverted ruby glass bowl enclosing the upper part of the lamp.

VENTILATION AND LAMP TEMPERATURES

There is no doubt that ventilation, however slight, usually cools the lamp bulb and some other parts of the unit to a certain extent, but this is ordinarily accompanied by a corresponding rise in temperature of other parts. One of the most important considerations from the standpoint of the National Electrical Code is the temperature of the wire where it is connected to the lamp socket. A considerable amount of data, some of which are shown in the table, indicates that ordinary ventilation does not always cool the wire and socket parts, but actually raises their temperature in many instances.

Unit	Lamp	Degrees Fahrenheit: Temperature of Wire — Unit Not Ventilated	Degrees Fahrenheit: Temperature of Wire — Unit Ventilated	Location of Ventilating Holes
	200-Watt Daylight	164	168	Top
	500-Watt Daylight	233	240	Top and Bottom
	200-Watt Gas-Filled	140 140	155 148	Top and Bottom Tube and Bottom
	200-Watt Gas Filled	125	125	Top
	200-Watt Gas-Filled	129	130	Tube

Wire Operating Temperature

JOURNAL OF THE American Institute of Electrical Engineers

PUBLISHED MONTHLY BY THE A. I. E. E.
33 West 39th Street, New York
Under the Direction of the Publication Committee

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Subscription. $10.00 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Phillipines; $10.50 to Canada and $11.00 to all other countries. Single copies $1.00. Volumes begin with the January issue.

Changes of advertising copy should reach this office by the 15th of the month for the issue of the following month.

Annual Convention at Swampscott

As this issue of the JOURNAL goes to press all arrangements have been completed for the 39th Annual Convention of the A. I. E. E., at Swampscott, Mass., and the distant members will have started on their way. The Convention Committee in Boston has shown great enthusiasm in planning a full program of trips of historic interest, inspection trips to plants in the vicinity, and a variety of entertainments. An unusually large attendance is expected. A detailed account of this convention will appear in the next issue of the JOURNAL.

Pacific Coast Convention

The Pacific Coast Convention will be held, as previously announced, at Del Monte, Calif., October 2-5. The program is practically decided upon and will combine engineering papers and entertainment features to make a most profitable and enjoyable meeting.

The technical sessions will be four in number, and most of the subjects will be in the nature of symposiums. The provisional technical program will be as follows:

TUESDAY, OCTOBER 2
AFTERNOON

Registration
Outdoor recreation

EVENING

Registration
Dancing

WEDNESDAY, OCTOBER 3
MORNING

Registration
President Jewett's Address
President-Elect Ryan's Address on *Researches Relating to High-Tension Transmission.*
Symposium by Transmission Engineers of the Great West on the Mechanical and Electrical Construction of Modern Power Transmission Lines, including Insulators for High-Voltage Lines.
(Title Later) C. B. Carlson, Southern California Edison Company.
Electrical Construction of Modern Power Transmission Lines and Insulators for High-Voltage Lines, by H. R. Wakeman and H. W. Lines, of the Portland Railway, Light & Power Company.
The Evolution of the High-Voltage Insulator, by J. Koontz, Great Western Power Company.
Desirable Forms of High-Tension Insulators, by F. G. Baum, Consulting Hydroelectric Engineer, San Francisco.
Design of the Anchor and Supporting Structures for the Carquinez Straits Crossing, by L. J. Corbett, Pacific Gas & Electric Company.
Special Features of Design of Transmission Tower Lines as Imposed by Electrical Conditions, by Walter Dreyer, Pacific Gas & Electric Company.
(Title later) M. T. Crawford, Puget Sound Power & Light Company.
E. R. Stauffacher, Southern California Company, and R. R. Robley, Portland and Railway, Light & Power Company, will each present a paper on *Group Operation of Systems Having Different Frequencies.*

AFTERNOON

Symposium by Transmission Engineers of the Great West on Water Wheel Construction, Operation and Governing, etc.
General Consideration of the Subject, by John Harrisberg, Puget Sound Power & Light Company.
Water Wheel Construction, Operation and Governing, E. D. Searing, Portland Railway, Light & Power Company.
A Study of Irregularity of Reaction in Francis Turbines, by R. Wilkins, Pacific Gas & Electric Company.
E. W. Breed, Pelton Wheel Company, general paper on this subject.
General Consideration of the Subject, by H. L. Doolittle, Southern California Edison Company.
Four Papers on High-Voltage Switches, Bushings, Lightning Arresters: D. W. Proebstel, Portland Railway, Light & Power Company; M. Michener, Southern California Edison Company; A. W. Copley, Westinghouse Electric & Mfg. Company; L. N. Robinson, Stone & Webster, Inc., Seattle.

EVENING

Presentation of the Edison Medal to Dr. R. A. Millikan, followed by an address by Dr. Millikan.
Dancing

THURSDAY, OCTOBER 4
MORNING

High-Voltage Insulation, by J. L. R. Hayden and C. P. Steinmetz, General Electric Company, Schenectady.
Power Resources of the United States (an illustrated address), by F. G. Baum, Consulting Hydroelectric Engineer, San Francisco.
Generating and Substation Machinery for Long Transmission Systems, by W. Smith, Westinghouse Electric & Mfg. Company.
Symposium on High-Voltage Transformer, including Transformer Bushings
Performance of Auto Transformers with Tertiaries under Short-Circuit Conditions, by J. Mini and R. Wilkins, of the Pacific Gas & Electric Company.
A. W. Copley, Westinghouse Electric & Mfg. Company.

L. J. Moore, San Joaquin Light & Power Company.
L. N. Robinson, Stone & Webster, Inc., Seattle.

AFTERNOON

Golf Tournament
17-mile sightseeing drive

EVENING

Banquet and dancing

FRIDAY, OCTOBER 5

MORNING

Symposium on Radio Communication as Applied to Power Transmission Networks:
J. Koontz, Great Western Power Company.
Experience with a 202-Mile Carrier-Current Telephone System, by E. A. Crellin, Pacific Gas & Electric Company.
R. Ashbrook, Southern California Edison Company.
Symposium on Theory and Practise in High-Voltage Operation:
R. C. Wood, Southern California Edison Company.
W. D. Shaw, Southern California Edison Company.
A. W. Copley, Westinghouse Electric & Mfg. Co.
Economics of Power Factor Control of Long High-Voltage Transmission Lines, by A. V. Joslin, Pacific Gas & Electric Company.
Methods of Voltage Control of Long Transmission Lines by the Use of Synchronous Condensers, by J. Koontz, Great Western Power Company.
Papers on Telephonic Communication (names of authors later).

AFTERNOON

Recreation, sports, sightseeing

EVENING

Leave for Post-Convention Trips, to Bay Region Substation, to the Sierra Nevada Power House and Hetch Hetchy Valley.

Further details of the program and entertainments will be printed in the next issue of the JOURNAL.

Papers for A. I. E. E. Convention

NOTICE TO AUTHORS—The Meetings and Papers Committee announces that papers intended for the 1924 Midwinter Convention must be received prior to October 12, 1923. Manuscripts received after this date will be considered only for subsequent meetings. In order to review, edit, print, and mail copies of more than a score of papers in advance of the conventions, three months are required. Much advanced engineering work is being done this year. A considerable part of the Midwinter Convention program is already made up of papers crowded out of the Swampscott Convention. Members preparing papers for any of the four conventions of 1924 are requested to send a preliminary note of the approximate title and probable date of completion to the Meetings and Papers Committee.

As to later meetings, papers intended for the Spring Convention must be received prior to January 15, 1924, and for the Summer Convention prior to March 24, 1924.

1922 Commission of Washington Award to Captain Robert W. Hunt

The Commission of Washington Award for 1922 was voted to Captain Robert W. Hunt and the presentation was made at the annual meeting of the Western Society of Engineers, held June 18, 1923. This 1922 award was made to Captain Hunt "For preeminent service in promoting the public welfare, for his pioneer work in the development of the steel industry in the United States and for a life devoted to the advancement of the engineering profession."

The award is made annually by a committee composed of nine representatives of the Western Society of Engineers and two each from the A. S. C. E., the A. I. M. E., the A. S. M. E. and the A. I. E. E. The award of the medal was established in 1917 by Past President J. W. Alvord of the Western Society "to be annually presented to an engineer whose work in some special instance, or whose services in general have been noteworthy for their merit in promoting the public good."

128th Meeting of A. I. M. & M. E.

The American Institute of Mining and Metallurgical Engineers will hold its 128th meeting in Ontario and Quebec, August 20-31. Eleven days' program is outlined, combining technical sessions, entertainments and numerous inspection trips to plants and mines in this vicinity.

Annual Meeting of New York Electrical Society

At its annual meeting for the election of officers June 7th, the New York Electrical Society unanimously elected the following ticket, with Vice-Presidents, Dr. Erich Hausmann, J. P. Alexander and J. L. Pitcher, as holdovers:

President, Philip Torchio; Vice-Presidents, Alfred Cane; E. H. Clarke, Harry T. Kidder; Secretary, T. C. Martin, Treasurer, T. F. Honahon.

Welded Pressure Vessels

For several years efforts have been made to draw up a code for the welding of unfired pressure vessels. Opinions of the best welding experts were not in agreement on many essential points. Fundamental, scientific knowledge, based on test data was not available. The American Bureau of Welding (Research Department of the American Welding Society), has completed a series of tests on some fifty tanks. The program involved an expenditure of over \$15,000. The test data, analysis of same, conclusions and recommendations to the Boiler Code Committee of the A. S. M. E. have been compiled in a report, copies of which may be obtained from the American Welding Society, 33 West 39th Street, New York, at \$1.50 to members and \$5.00 to non-members.

Ratio of Direct and Alternating Test Voltage with Especial Reference to Impregnated Paper Cables

The ratio between the direct and root-mean-square alternating voltages which will produce failure of insulation depends upon:
(a) the time of application of the voltage
(b) the nature of the insulation
(c) the temperature
(d) and possibly the thickness of insulation

Confining our attention to impregnated paper insulation, and to short-period applications of voltages, *i. e.*, periods so short that the average dielectric loss will not affect the dielectric strength, we find the ratio to be 1.4 for fluid oil, somewhat higher, say 1.8 for impregnated paper at 100 deg. cent. and rising to higher values in some cables to 2.4 at 25 deg. cent.

The value 2.4 for 25 deg. cent. is however apparently not a constant.

M. Weiset (*E. T. Z.* Jan. 15, 1920 p. 48) experimenting with a Delon rectifier found a ratio of 2.46 for cable lengths of 100 meters or more, but obtained lower ratios for shorter lengths (1.7 to 1.8 for 3 meters).

Correspondence with M. Jules Delon of Lyon, elicited the statement that the ratio according to his tests is 2.4.

Mr. Wallace S. Clark, writing under date of Aug. 16, 1922, said: "Tests made on cable manufactured by the General Electric Co., mineral base compound, showed, on single-conductor cables with five minutes test duration, at 25 deg. cent. a ratio of 2.4 to 1; at 100 deg. cent. a ratio of 1.77 to 1 in.

Results obtained with commercial tests of cables on which, however, too much reliance should not be placed, indicate that the ratio depends upon the compactness of the paper fibers, *i. e.*, very compact paper immobilizes the oil in somewhat the

same way as is done by lowering its temperature. This immobilization which is probably ionic, as indicated in a paper by Del Mar and Hanson, JOURNAL A. I. E. E. June 1922, seems to be the determining factor in the ratio.

As the compactness of the paper in old cables is quite unknown, it would seem unsafe to assume any ratio for such cables. On the other hand the compactness of the paper is likely to differ in different makes of modern cables and there is danger of spoiling cables which would give excellent results with alternating current, if a direct voltage based on the ratio 2.4 is used in testing.

A paper by Phelps and Tanzer, JOURNAL of A. I. E. E., March 1923, indicates that the practical solution of this problem may be found in applying a comparatively low direct voltage and observing the behavior of the insulation as revealed by its current-time characteristic. A manufacturer of electrical machinery has come to a similar conclusion with respect to machine insulation.

The subject is one that demands more experimental work, but such work would be very expensive on account of the large number of cables that would have to be destroyed.

Any information on this subject which members may contribute will be appreciated by the Standards Committee. Communications should be addressed to the Secretary of the Committee.

National Research Council

Under this heading are included news items of the National Research Council and its activities and summaries of progress made by the research committees of its Division of Enigineering during the current month.

The purpose of the following items is to give a resumé of the progress made during the month and to point out the objects and method of attack for each project.

Electrical Insulation

Object: To lay a foundation of fundamental knowledge of the phenomena of electrical insulation on which the solution of practical problems can be based.

Method of attack: Present aims are (1) To formulate a statement of general and specific problems of insulation requiring attack through experimental research, (2) The preparation of a critical review of the best existing information concerning each problem and the compilation of specific investigations needed to secure further information, (3) The development of a plan for organized effort in attacking these problems and the assignment of specific problems to particular laboratories and individual experimenters, and the stimulation of the work by conferences or otherwise, (4) The coordination and publication of the results of these investigations.

Progress: A comprehensive statement of the problem including the history, functions, and properties of insulation, plan of attack and problems needing investigation, was published in the June 1923 JOURNAL.

Welded Rail Joints

Object: To improve each of the four methods now used commercially for making welded rail joints for street railways.

Method: Data will be secured on the present state of the art in making the electric arc, seam, thermit, resistance, and cast welded types of joints, and a program of investigations planned looking towards the improvement of each type.

Progress: A thoroughly representative committee has been organized including street railway experts, scientists, testing experts and welding engineers.

A 73-page bulletin has been compiled by the aid of replies received to a questionnaire showing the variety of methods in vogue and technique employed in making street railway joints.

A program calling for a series of test specimens, representative of the different methods employed in making street railway joints has been prepared, and most of the test specimens called for in the program have been made and shipped to the various laboratories where they will be given tensile, bending, conductivity, drop and repeated impact tests. Two machines will be built at the Bureau of Standards for the use of the Committee, one of them, a rotary service testing machine will give the joints the same wear in one month that they would get in service inapproximately ten years; the other is designed to give test joints repeated blows of a magnitude equal to that received in service from a car wheel passing over a cupped joint. The designs of the two machines have been completed and an appropriation of $14,000 was made at the June 1st meeting of the Executive Committee for their erection. Funds and material needed to complete the $80,000 program outlined have been promised or secured.

Pressure Vessels

Object: To assist the Boiler Code Committee of the American Society of Mechanical Engineers in drawing up a satisfactory code governing the use of welding in the construction of unfired pressure vessels.

Progress: A report covering 150 pages has been completed and published by the American Welding Society, 29 West 39th Street, New York. The report includes test data obtained from the destructive tests of about 50 tanks and the analysis of the test results.

Training of Welding Operators

Object: The preparation of an outline for the training of welders which will, if followed, insure the training of competent welders within a minimum of time and effort.

Progress: A personnel research involving the experience of experts of the Federal Board of Vocational Education, National Research Council and American Welding Society, was made and a course prepared. This course consists of two parts, one on the training of oxy-acetylene welders, and the other on electric welders. The former has been reprinted in bulletin form by the American Welding Society and is available for distribution.

Advisory Board on Highway Research

Object: To assist in outlining a comprehensive national program of highway research and the coordinating activities thereunder, to organize specific projects, and to act in a general advisory capacity.

Method: The Board comprises representatives of 17 organizations interested in highways, transport thereon, vehicles, and highway economics. Experimental work involving more than one million dollars is in progress by Federal and State departments, universities, industries and organizations.

Progress: The Director has published a comprehensive national scheme for highway research and several papers before engineering and other associations. A census of highway research in progress, or recently completed, and a bulletin on the work by the Board and its cooperating organizations, has been prepared and published. A report on the apparatus used in highway research projects in the United States is in press.

Heat Treatment of Carbon Steel

Object: To increase the knowledge of the influence of heat treatment on the mechanical properties of carbon steel; especially to learn the conditions which most advantageously set up the sorbitic state, the most valuable for engineering purposes.

Method: To subject specimens of steel of the carbon contents most used for engineering work, 0.34 per cent, 0.52 per cent, 0.75 per cent, and most suited to sorbitizing, to various heat treatments, and to test the mechanical properties thus induced.

Progress: A comprehensive report by Messrs. Henry M. Howe, Francis B. Foley and J. Winlock, consisting of 47 pages and including test data, charts, curves, photographs and formulas, was published recently by the American Institute of Mining and Metallurgical Engineers. The Committee is being reorganized and a program of investigations is being prepared to secure information and data still lacking.

AMERICAN ENGINEERING COUNCIL

MEETING OF EXECUTIVE BOARD, JUNE 8-9

Developing participation by engineers in public affairs was strongly evident at the last meeting, held in St. Paul, June 8-9, of the Executive Board of the American Engineering Council of the Federated American Engineering Societies. General round table discussion revealed that local groups in many sections of the country are taking a constructive part in solving community problems. This local effort embraces traffic, smoke abatement, water supply, city planning, state and municipal legislation relating to engineering matters and related subjects.

The Committee on Transportation, which is considering ways and means whereby the Federated American Engineering Societies may be of constructive service in relation to the transportation problem of the nation, was authorized to continue its studies.

The Committee on Storage of Coal reported that its plans had been perfected and that the survey was well under way. Subcommittees are being formed in some eighty centers. Each member society has been requested to designate a member on each subcommittee. The response to these requests has been gratifying, according to the committee. Dean Perley F. Walker of the University of Kansas, Lawrence, Kan., has been authorized by the Committee on Storage of Coal to devote all of his time for the next few months to the work. He will visit the various centers and assist the subcommittees in organizing and executing their respective tasks.

The Executive Board requested the Committee on Reforestration to submit at an early date a concrete plan of action, whereby this work may be more effectively pursued. Chairman Charles H. MacDowell of Chicago submitted a written report stating that two addresses on the subject had been broad cast from Pittsburgh and plans were being developed to do likewise elsewhere. J. C. Ralston addressed the Board, saying that the Associated Engineers of Spokane were vitally interested in reforestration and were prepared to cooperate with the Federation. Definite work and results, it was said, are to be expected.

PERSONAL MENTION

J. Wallace has recently formed a connection with the Westinghouse Electric & Mfg. Company of Los Angeles, Calif.

C. A. Fullman has accepted a position with the Nebraska Gas & Electric Company at York, Nebraska, as Chief Electrician.

Gerard Swope, President of the General Electric Company, was awarded the degree of Doctor of Science at Rutgers College on June 12.

Geo. H. Stonsell has resigned his position with the Fisher Body Ohio Company, and is now employed by the Consumers Power Company at St. Johns, Michigan.

Kazutaro Kishida has recently retired from the Jitsuyo Jidasha Seizo Co. in Osaka, and is now employed by the Mitsubishi Electrical Engineering Co., Ltd., in Kobe, Japan.

John W. Reed has severed his connection with the Holtzer, Cabot Electric Company and is now employed by the Peerless Electric Company of Warren, Ohio, as District Manager.

A. E. Ulrich recently accepted the position of Chief Engineer with the Ferguson Furnace Company at Toledo, O. Previously he was connected with Joseph T. Ryerson & Son, Chicago, Ill.

Walter C. Whitaker, who was formerly connected with the Bureau of Power & Light, Los Angeles, Calif., has accepted a position with the General Electric Company, Los Angeles, Calif.

G. J. Newton has resigned from the George Construction Company and will devote his time to the design of underground distribution systems, with office at 6100 Spruce St., Philadelphia, Pa.

Lorenz W. F. Carstein, formerly Deputy Commissioner of Public Works, of the city of Long Beach, has established himself in the practise of engineering at 50 Church Street, New York City.

Ranald J. Harvey, who was Chief Assistant to Sir J. Duncan Elliot until the latter's recent retirement from business, is now engaged with Messrs. Robert White & Partners, London, England.

T. W. Carraway has sold his interest in the Carraway Engineering Co. to accept a position as Chief Engineer with the San Antonio Machine and Supply Company, San Antonio, Txas.

A. A. Hurwitz has severed his connection with the Dickson Construction Company, Hagerstown, Md., and is now an electrical draftsman at the Baldwin Locomotive Works, Philadelphia, Pa.

Philip C. Bangs has resigned as Junior Transmission Engineer of the Southern Bell Telephone Company, Atlanta, Ga., and is now City Sales Engineer of the Fulton Electric Company, Atlanta, Ga.

Charles F. McLaughlin, formerly an engineer and citrus fruit grower at McAllen, Texas, has formed a connection with the Tennessee Inspection Bureau, Nashville, Tenn., as a Special Service Engineer.

Harrison A. Martin, until recently employed in the A-C. Engineering Dept. of the General Electric Company is now an electrical designer with the Electric Bond & Share Company, New York, N. Y.

Chester C. Dodge, who was recently employed in the Marine Engineering Department of the General Electric Company, is now connected with Stone & Webster, Inc., Boston, Mass. in its Electrical Division.

Frank P. Smith, who was recently connected with the Brooklyn Edison Company, is now with McClellan & Junkersfeld as Assistant Electrical Superintendent at the Cahokia Power Plant, St. Louis, Mo.

Joseph J. Thomason is engaged as Chief Engineer of the City of Corinth, Miss., in the construction and operation of a new municipal light and water plant. He was previously connected with the W. A. Fuller Company of St. Louis, Mo.

H. W. Nichols, of the Research Dept. of the Western Electric Company has been awarded the Fahie Premium by the Institution of Electrical Engineers of London, for his lecture before the Institution on "Transoceanic Wireless Telephony."

Alfred J. T. Taylor resigned from the presidency of the Taylor Engineering Company, at the beginning of the year, to become President of Combustion Engineering Corporation, Ltd., with headquarters in Toronto, and offices in Montreal, Winnipeg and Vancouver.

George A. Iler has recently joined the forces of the Pennsylvania-Ohio Power & Light Co., in charge of the Engineering and Line Department. He was formerly radio engineer for

the *Atlanta Journal*, having built and operated the broadcasting station of that newspaper.

Andrew S. Tait has returned to the sales field as District Manager of the Packard Electric Company, Ltd., with headquarters at Montreal. He was previously with the Canadian General Electric Company as District Engineer, with which company he was associated for 13 years.

W. R. Whitney, director of the Research Laboratory of the General Electric Company, was recently elected a member of the corporation of the Massachusetts Institute of Technology for a term of five years. He graduated from M. I. T. in 1890 and has been a non-resident professor of theoretical chemistry at that institution for some time.

H. M. Van Gelder has been made a partner of Stovel & Brinkerhoff, the name being changed to Stovel, Brinkerhoff & Van Gelder, New York, N. Y. He was formerly Electrical Engineer and Managing Engineer of Westinghouse, Church & Kerr and recently Project Engineer on railroad electrification work with Gibbs & Hill.

H. G. MacMurchy, who for the past four years has been in the Engineering Dept. of the Aluminum Company of America at Pittsburgh, is now connected with the Phoenix Utility Co. of Allentown, Pa., as Electrical Construction Engineer in charge of the installation of electrical equipment in a new steam-electric station for the Memphis Power & Light Co., of Memphis, Tenn.

F. M. Feiker, formerly Vice President of the McGraw-Hill Company, Inc. and more recently on leave of absence as Special Agent to the Department of Commerce at Washington, after his return from Washington will be associated with the staff of the Society for Electrical Development, New York, N. Y. He will retain a consulting relation to the McGraw-Hill Company, Inc., and he will continue in a similar capacity his relation to the problems of personnel and organization of the Department of Commerce at Washington.

Obituary

Louis Matty, a French citizen, for many years in engineering work in Mexico and South America, died on September 27, 1922, at the age of forty-five. His work was chiefly connected with installing hydroelectric and other electrical plants in Mexico and was a pioneer in that field. At the time of his death he was Chief Engineer of the Cia. Hidroelectrica e Irrigadora del Chapala, S. A. Mr. Matty became an Associate of the A. I. E. E. in 1923.

Edwin W. Babcock died on May 13, 1923, at the age of fifty. He received his education at the Manual Training High School at Philadelphia, and was with Dr. W. A. Drysdale, Consulting Engineer, of Philadelphia, for three years, with the Philadelphia Edison Company one year, and in 1897 he went with the Brooklyn Edison Company. He remained with this company until the time of his death, having held the position of Superintendent of Electrical Construction since the time of his entrance into the Institute as an Associate in 1903.

Dr. Louis Bell, consulting engineer of Boston, Mass. and Member of the Institute died at the Deaconess Hospital, Boston, on the morning of June 14th. Dr. Bell who was born at Chester, N. H. in 1864, was a graduate of Dartmouth, 1884, and received the degree of Doctor of Philosophy from Johns Hopkins in 1888. He organized the electrical engineering department at Purdue University and was professor there in 1888-89. In 1890 he became chief engineer of the newly organized department of electric power transmission of the General Electric Co., and designed and installed the first polyphase plants in this country for power, lighting and railway service. He has lectured on electrical engineering and on public lighting at M. I. T. and Harvard and since 1895 carried on a consulting practise chiefly in connection with power transmission. Dr. Bell entered the Institute as an Associate in 1890 and was transferred to Member that year. He served as a Manager of the A. I. E. E. from 1891 to 94.

Past Section and Branch Meetings

PAST SECTION MEETINGS

Atlanta.—May 24, 1923. Two papers were presented: "Inductive Coordination as a Problem and a Movement," by H. L. Wills and W. V. Lovell, presented by Mr. Wills, and "Inductive Coordination, Its Necessities and Accomplishments," by D. H. Keyes and K. L. Wilkinson, presented by Mr. Keyes. Discussion followed. Attendance 60.

Baltimore.—May 17, 1923. Subject: "Lighting of Factories and Office Buildings." Speaker: Earl A. Anderson, of the National Lamp Works. Attendance 46.

Boston.—May 15, 1923. Election of officers as follows: Alexander Macomber, Chairman; F. S. Dellenbaugh, Vice Chairman; Ira Cushing, Sec. and Treasurer. A social meeting and supper followed. Attendance 174.

Chicago.—May 21, 1923. Election of officers as follows: J. E. Kearns, Chairman; Carl Lee, Vice Chairman; Geo. H. Jones, Secretary. A. W. Hull, of the Research Laboratories of the General Electric Company spoke on "Vacuum Tubes for Power Service." Attendance 250.

Cleveland.—May 16, 1923. A banquet preceded the meeting, at which election of officers was held. Officers for the coming year are as follows: G. B. Schneeberger, Chairman; C. P. Cooper, Chairman Papers Committee; T. D. Owens, Secretary-Treasurer. It was announced by the Membership Committee that the Cleveland Section had obtained a 183 per cent of its quota of membership. President Frank B. Jewett addressed the meeting, speaking on "Problems Concerning the Institute and Manner in which the Officers have Tried to Solve Them." Attendance 125.

Columbus.—April 27, 1923. First Annual Convention. In the afternoon the meeting was held in the auditorium of the Columbus Railway Power & Light Co. Two papers were presented: "Some Recent Developments in High-Tension Insulators," by Arthur O. Austin and "Carrier Telephone and Telegraph Systems," by Herman A. Affel. An inspection trip through the Columbus Central Office of the Ohio Bell Telephone Company followed. There was a dinner at the Columbus Athletic Club. In the evening there were moving pictures and an inspection trip through the Research Laboratories of the General Electric Company, after which Saul Dushman, of the General Electric Company, presented a paper on "Electrons in Engineering." Attendance 89.

May 25, 1923. Business meeting and election of officers as follows: E. M. Fitz, President; and A. W. Janowitz, Secretary-Treasurer. Attendance 20.

Connecticut.—May 25, 1923. Eighteenth Annual Meeting was held at the Lawn Club, New Haven, Conn. Preceding the meeting there was a dinner, at which seventy members and guests were present. Officers for the coming year were elected as follows: Edward H. Everit, Chairman; Archer E. Knowlton, Secretary-Treasurer. Hugh L. Cooper, Consulting Engineer, of New York City, presented a paper on "The Proposed New St. Lawrence." The lecture was illustrated by slides and motion pictures. Attendance 75.

Denver.—May 25, 1923. This was a general engineering meeting held under the auspices of the Colorado Engineering Council, at the University of Colorado. S. M. Vauclain, President of the Baldwin Locomotive Works, was the speaker of the

evening, taking as his subject "Undermining Engineering." A dinner was served to 300 people. Attendance 1500.

June 8, 1923. Annual Meeting. Subject: "Some Problems Pertaining to the Interconnection of High-Tension Power Systems." Speaker: W. W. Lewis, of the General Electric Company.

Erie.—May 14, 1923. Election of officers as follows: M. W. Metzner, Chairman; L. H. Curtis, Secretary. Prof. Dayton C. Miller, of the Case School of Applied Science, gave an illustrated lecture on "The Science of Musical Sounds." Attendance 210.

Fort Wayne.—May 27, 1923. Inspection trip to a dam site near Monticello where brief speeches were made by engineers in charge of layout and construction of the dam. Election of the following officers was announced: C. C. Grandy, Chairman; Howard Miller, Vice Chairman; L. C. Yapp, Secretary. Attendance 107.

Lehigh Valley.—May 24. 1923. This was the Annual Meeting, at which the following officers were elected: H. G. Harvey, Chairman; George W. Brooks, Secretary-Treasurer. It was announced by the Membership Committee that this Section had obtained 144 per cent of its quota of membership. V. Karapetoff, of Cornell University, was the speaker of the evening, taking as his subject: "Recent Advances and Problems in Electrical Applications." Discussion followed. Attendance 192.

Los Angeles.—April 24, 1923. Subject: "The Application of Protective Relays to Alternating-Current Systems." Speaker: E. R. Stauffacher, Protection Engineer, Southern California Edison Company. There were lantern slides shown. A relay demonstration panel was exhibited which showed the action of modern relays under conditions of short circuit on a substation bus or on either of two parallel transmission lines between a generating plant and a substation. Discussion followed. Attendance 93.

May 19, 1923. The afternoon and evening were devoted to a combined inspection trip, dinner and lecture. A trip was made to the new 220-kv. Laguna-Bell substation of the Southern California Edison Company. The party then went to the California Institute of Technology, where dinner was served and a lecture was given afterward. Attendance 200.

Minnesota.—May 17, 1923. Inspection trip to the Minnesota Mazda Lamp Factory at Minneapolis. A luncheon was served. Attendance 75.

June 1, 1923. This was a dinner-dance, at which officers for the ensuing year were elected as follows: H. W. Meyer, Chairman; N. W. Kingsley, Secretary; E. Marshall, Director. Attendance 89.

Philadelphia.—May 14, 1923. Subject: "Power Factor and its Relations to the Industrial Plant." Speaker: B. Frank Gaskill, of the Philadelphia Electric Company. Those who participated in the discussion were: L. W. W. Morrow, C. W. Bates, C. W. Drake, H. W. Smith, O. C. Roff, L. H. Rittenhouse, C. D. Fawcett, M. E. Skinner and Mr. Burkhart. There was an informal dinner preceding the meeting. Attendance 210.

Pittsburgh.—May 15, 1923. Subject: "Remote Operation of Electrical Apparatus by Means of Supervisory Control." Speaker: R. J. Wensley. Attendance 180.

Portland.—March 27, 1923. Subject: "Ultra Violet Ray." Speaker: R. E. Tucker. Attendance 110.

May 8, 1923. Subject: "The New 6000-kv-a. Powerdale Development on Hood River, Oregon." Speaker: H. H. Scholfield, Chief Engineer, Pacific Power & Light Company. A moving picture was shown, depicting the development of signal communication. Attendance 131.

June 7, 1923. Election of officers. Dancing and cards were enjoyed for the remainder of the evening. Attendance 160.

Providence.—June 1, 1923. Election of officers as follows: Howard A. Stanley, Chairman; Warren B. Lewis, Vice Chairman; Frederick N. Tompkins, Secretary-Treasurer. Subject: "Radio Explained by Analogies." Speaker: Horace V. S. Taylor, of the Westinghouse Elec. & Mfg. Co. Attendance 55.

Seattle.—April 19, 1923. Subject: "The Columbia River Project." Speaker: Willis Batcheller, of Seattle. Discussion followed the presentation of the paper. Attendance 64.

Spokane.—May 31, 1923. Election of officers as follows: E. R. Hannibal, Chairman; G. S. Covey, Vice Chairman; James S. McNair, Secretary-Treasurer. Attendance 28.

Springfield.—June 1, 1923. Annual election of officers as follows: C. M. Cross, Chairman. C. F. Hood, Superintendent of the American Steel & Wire Co., of Worcester, Mass., gave a talk on "The Manufacture and Installation of High-Tension Cables." Lantern slides and moving pictures illustrated the lecture. Attendance 28.

Toledo.—May 18, 1923. Trip to the Ford Plate Glass Co. Attendance 38.

Urbana.—April 20, 1923. Prof. E. W. Lehman, of the University of Illinois lectured on "The Use of Electricity in Agriculture." Otto G. Tinkey explained the Delco farm lighting plant. Attendance 60.

Utah.—May 21, 1923. Inspection trip to Terminal Substation of the Utah Power & Light Co., where dinner was served. The following officers were elected: C. R. Higson, Chairman; Hiram W. Clark, Secretary-Treasurer. Attendance 115.

Washington, D. C.—May 8, 1923. Election of officers as follows: L. M. Evans, Chairman; J. H. Ferry, Vice Chairman; A. F. E. Horn, Secretary-Treasurer. Prof. Louis D. Bliss, of the Bliss Electrical School, Takoma Park, Md., gave a talk on "Electrical Fakes." Attendance 60.

Worcester.—May 10, 1923. Frank B. Jewett, National President of the A. I. E. E., gave a talk on "The Present and Future of Industrial Research." The following officers were elected: L. E. Pierce, Chairman; H. O. Hilton, Vice Chairman; Stuart M. Anson, Secretary-Treasurer. Attendance 35.

PAST BRANCH MEETINGS

University of Arizona.—May 17, 1923. Subjects: "The Colorado River Compact," by H. Hoveland, "The Irrigation Problem of the Colorado River," by A. Zander, and "Power Developments from the Colorado," by Paul Cloke. Attendance 29.

Armour Institute of Technology.—May 17, 1923. Election of officers. Subject: "Operation of Broadcasting Station KYW." Speaker: E. A. Klein. Attendance 40.

Brooklyn Polytechnic Institute.—May 11, 1923. Subject: "The Neutrodyne Receiver." Speaker: Prof. L. M. Hazeltine, of Stevens Institute. Attendance 125.

May 18, 1923. Election of officers. Attendance 35.

Carnegie Institute of Technology.—May 10, 1923. Annual banquet and election of officers. Attendance 54.

Case School of Applied Science.—May 10, 1923. Banquet and social meeting. Attendance 45.

Clemson College.—May 10, 1923. Election of officers. Attendance 10.

University of Colorado.—May 23, 1923. Election of officers. Attendance 30.

Denver University.—May 11, 1923. Inspection trip through power plant of Denver Tramway Company. Attendance 26.

May 29, 1923. Business meeting. Attendance 14.

Lafayette College.—April 7, 1923. Subject: "Proposed Holland Electric Plant of the Pennsylvania Edison Company." Speaker: Mr. Jones of the Pennsylvania Edison Company. Attendance 18.

April 21, 1923. Review and discussion of current periodicals by different members of the branch. Attendance 19.

May 12, 1923. Subject: "The Hauto Mouth of Mine Electric Power Station." Speaker: Mr. Loyd, of the Pennsylvania Light & Power Company. Attendance 21.

Lehigh University.—May 24, 1923. Election of officers. The meeting adjourned to attend the Lehigh Valley Section

meeting, at which Prof. V. Karapetoff spoke on "Present Day Problems in Electrical Engineering." Attendance 30.

Lewis Institute.—May 14, 1923. Shop trip through plant of Allis-Chalmers Mfg. Co., Milwaukee, Wis. Attendance 7.

May 28, 1923. Illustrated lecture on "Features of the Commonwealth Edison Company's Service in Chicago," by Mr. Alexander Bailey. Attendance 53.

Milwaukee School of Engineering.—May 18, 1923. John D. Ball, Planning Engineer for the Edw. Schuster Company gave a lecture on "Organization." Attendance 46.

May 25, 1923. Inspection trip through the Cutler-Hammer Plant. Attendance 54.

University of Minnesota.—June 6, 1923. Election of officers. Attendance 52.

Montana State College.—May 15, 1923. Election of officers. C. A. Champ, of the General Electric Company of Butte, gave a lecture on "Application of Electricity to Mining." Attendance 85.

University of North Carolina.—May 24, 1923. Election of officers. There was a talk by Prof. P. H. Daggett. Attendance 32.

Northeastern University.—May 28, 1923. Business meeting. Attendance 19.

Oklahoma A. & M. College.—May 7, 1923. Subject: "The Principles of Radio," by Dr. J. H. Cloud. Two moving pictures were shown "The Queen of the Waves" and "The Wizard of Wireless." Attendance 41.

University of Okalahoma.—May 17, 1923. Election of officers and social meeting. Attendance 24.

Oregon State Agricultural College.—May 16, 1923. Election of officers and social meeting. Attendance 21.

University of Pennsylvania.—May 24, 1923. Election of officers and social program. Attendance 36.

Purdue University.—May 8, 1923. Subjects: "The Causes of Error in Current Transformers," by R. B. Marshall and "Underground Distribution of a Lighting System for Purdue University," by T. F. Hilderbrand. Attendance 26.

University of Southern California.—May 16, 1923. Subject: "Heat Engineering and its Application to Electrical Engineering," by Mr. Odd, and "Electrical Engineering Education," by Prof. Schuster. Attendance 20.

Stanford University.—May 24, 1923. Initiation of candidates. Attendance 33.

May 29, 1923. Election of officers. Attendance 22.

May 31, 1923. A banquet was given in honor of H. J. Ryan, National President-Elect of the A. I. E. E. Attendance 34.

Syracuse University.—May 4, 1923. Subject: "Power Requirements." Speaker: William Adams. Attendance 16.

May 18, 1923. Subject: "Ships and Ship Building." Speaker: Donald L. Baxter. Attendance 17.

May 25, 1923. Subjects: "Commercial Electric Vehicles," by Clifford E. Huntley, "The Utica Electric Power System," by Gordon Gifford, "Coal Economy of the Small Steam Power Plant," by Raymond F. Port. Attendance 15.

A. & M. College of Texas.—May 30, 1923. Election of officers and awarding of prize for best paper of the year to G. K. Clement. Short address by F. C. Bolton, Dean of the School of Engineering, summarizing work of the Branch for the year. Attendance 50.

University of Washington.—May 8, 1923. There was a banquet, after which Mr. Wiley of the C. M. & P. S. talked on "The Electrification Department of the C. M. & P. S." Attendance 60.

University of Wisconsin.—May 9, 1923. Election of officers. There was a paper by F. P. Way on "Rates and Rate Making." Attendance 30.

Engineering Societies Library

The library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m to 6 p. m.

BOOK NOTICES (May 1-31, 1923)

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statements made; these are taken from the preface or the text of the book.

All the books listed may be consulted in the Engineering Societies Library.

BUSINESS CYCLES AND UNEMPLOYMENT; Report and Recommendations of a Committee of the President's Conference on Unemployment.

N. Y. & Lond., McGraw-Hill Book Co., 1923. 405 pp., charts, tables, 9 x 6 in., cloth. $4.00.

The President's Conference on Unemployment met in Washington in September, 1921, under Secretary Hoover's chairmanship, primarily to consider relief for the millions of unemployed resulting from the business slump of 1921. During the meeting, it was recommended that an investigation be made of the whole problem of unemployment and of methods of stabilizing industry so that business depressions would be prevented, and a committee for this study was appointed.

This volume contains the report of the latter committee, with its recommendations, and also the report of an investigation made, at the request of the Committee, by the National Bureau of Economic Research. The latter report discusses the relation of business cycles to unemployment, cyclical fluctuations in employment and proposed remedies for cyclical unemployment.

ELECTRIC CRANES AND HAULING MACHINES.

By F. E. Chilton. Lond. & N. Y., Isaac Pitman & Sons, 1923. (Pitman's technical primers). 114 pp., illus., diagrs. 6 x 4 in., cloth. 85c.

The object of this book is to describe a number of the more generally used types of electric cranes and hauling machines, together with a few of the accessory specialties used with them, and to explain their methods of operation. The subject is treated in a simple descriptive manner, on broad general lines. Only the most modern and commonly used appliances are included.

ELECTRIC MOTORS......vol 1. Chiefly Concerning Direct Current.

By Henry M. Hobart. Third edition. Lond., & N. Y.' Isaac Pitman & Sons, 1923. 412 pp., illus., diagrs., tables, 9 x 6 in., cloth. $4.50.

An advanced treatise by an experienced designer, in which matters of theoretical and practical interest are discussed. The present edition has been completely revised and rewritten. While this volume is mostly about direct-current motors, the author has made no attempt to separate alternating and direct-current questions sharply, and has included certain important matters in the second volume.

ENGLISH AND ENGINEERING.

By Frank Aydelotte. Ed. 2. N. Y. & Lond., McGraw-Hil Book Co., 1923. 415 pp., 7 x 5 in., cloth. $2.00.

Dr. Aydelotte sets forth the purpose of his book to be:

(1) To teach the student to write not by telling him how, not by doing his thinking for him, but by stimulating him to think for himself about his own problems, about his work and its place in the world;

(2) To lead the engineering student to think of the occupation for which he is preparing himself not as a trade but as one of the liberal professions;

(3) To lead him to see how his work of designing material conveniences for men is bound up with the spiritual advancement of the race—with the world of science, of literature and of moral ideals.

The range of the thirty-eight essays in the book embraces many kinds of men and many kinds of writing from the works of Macaulay and Ruskin to the writings of living engineers and advertisements of manufacturers.

FINANCIAL INCENTIVES FOR EMPLOYEES AND EXECUTIVES.

By Daniel and Meyer Bloomfield. N. Y., H. W. Wilson & Co.; Lond., Grafton & Co., 1923. (Modern Executive's Library). 2 vol., 8 x 5 in., cloth. $4.80.

A handy compilation of articles on wage systems, bonus plans, thrift plans and other plans for rewarding employees, classified and arranged for convenient reference. Part of the material is reprinted from periodicals and reports, the remainder is original with the authors. The work covers a wide field and gives the practise of many firms.

INDUSTRIAL ELECTRIC HEATING.

By J. W. Beauchamp. Lond. & N. Y., Isaac Pitman & Sons, 1923. (Pitman's technical primers). 118 pp., illus., diagrs., tables, 6 x 4 in., cloth. $.85.

The primary object of this book is to bring together, for the benefit of the engineer and student, information on the applications of electric heating, particularly to other purposes than furnace and welding work. The book is intended to suggest possible applications and thus to stimulate further inquiry by manufacturers and others who could use electric heating, by calling attention to the variety of uses which it now has.

KALENDER UND HANDBUCH FUR BETRIEBSLEITUNG UND PRAKTISCHEN MASCHINENBAU, 1923.

By Hugo Güldner. Leipzig, H. A. Ludwig Degener, 1923. 2 vols., diagrs., tables, 6 x 4 in., limp cloth. $1.00.

A pocketbook designed to meet the wants of engineers engaged in management and operation, or in the manufacture of machinery, rather than in design. Issued in two parts, the first containing the greater part of the text and discussing the material of machines, machine parts, prime movers, power transmission and auxiliary machinery. Volume two treats of management and also contains mathematical tables. The work is published in inexpensive form and is revised each year.

ROBERT FULTON AND THE SUBMARINE.

By Wm. B. Parsons. N. Y., Columbia University Press, 1922. 154 pp., illus., port., 10 x 7 in., cloth. $4.00.

An interesting record of Fulton's submarine boats, of his experiments in France and England and of his unsuccessful attempts to interest the governments of those countries in his invention. Much of the material is here published for the first time and is taken from recently discovered descriptions written by Fulton himself.

STROME UND SPANNUNGEN IN STARKSTROMNETZEN ALS GRUNDLAGE ELEKTRISCHER LEITUNGSBERECHNUNGEN.

By Josef Herzog, u. Clarence Feldmann. Berlin u. Leipzig, Walter de Gruyter & Co., 1923. 110 pp., diagrs., tables, 6 x 4 in., boards. .25.

A concise presentation of the theoretical considerations in the design of distributing systems for electric power. The little volume is intended as a vade-mecum for the engineer, not as a textbook for the student. The methods for calculating distributing networks are set forth explicitly, in spite of the briefness of the text.

Addresses Wanted

A list of members whose mail has been returned by the Postal Authorities is given below, together with the addresses as they now appear on the Institute records. Any member knowing the present address of any of these members is requested to communicate with the Secretary at 33 West 39th Street.

1.—M. G. Bindler, 2 Margaret St., Derby, England.
2.—F. G. Burka, 10 Roulo Ave., W. Fort St. Sta., Detroit, Mich.
3.—L. Clyde Chatfield, Matangi Esplanade, New Brighton, Christchurch, N. Z.
4.—Harold B. Clymer, 26 Klein Ave., Trenton, N. J.
5.—Roy Danner, Amer. Motor Body Co., Detroit, Mich.
6.—R. A. Harman, c/o Tar Heel Mica Co., Plumtree, N. C.
7.—Howard W. Key, 506 W. 32nd St., Austin, Texas.
8.—Daniel Maass, Compania De Luz Electrica De Sta. Ana, Rep. De El Salvador, Central America.
9.—R. H. McKibben, Cortaro, Pima County, Ariz.
10.—T. H. McWhirk, 153 East 86th St., New York, N. Y.
11.—Edwin C. Miller, 968 Morris Ave., Bronx, New York, N. Y.
12.—P. B. Munro, 462 Sherbrooke St., Peterboro, Ont.
13.—Karl W. Radcliffe, Apt. B, 174 13th St., Milwaukee, Wis.
14.—Kalman C. Tissinay, Westinghouse E. & M. Co., Newark, N. J.
15.—Lester E. Tunison, Pickwick Hotel, 833 So. Grand Ave., Los Angeles, Calif.
16.—Peter C. Winther, Jr., 174 Martin St., Milwaukee, Wis.

Employment Service Bulletin

OPPORTUNITIES.—Desirable opportunities for service from responsible sources are announced in this Bulletin, and no charge therefor is made.

MEN AVAILABLE.—Under this heading brief announcements will be published without charge to the members. Announcements will not be repeated except upon request received after a period of three months, during which period names and records will remain in the active files.

NOTE. Notices for the JOURNAL should be addressed ***EMPLOYMENT SERVICE, 33 West 39th Street, New York, N. Y.,*** *the employment clearing house of the National Societies of Civil, Mechanical, Mining and Electrical Engineers.*

Notices for the JOURNAL are not acknowledged by personal letter, but if received prior to the 16th of the month will appear in the issue of the following month.

All replies to either "Opportunities" or "Services Available" should be addressed to the key number indicated in each case and forwarded to ***EMPLOYMENT SERVICE,*** *as above.*

Replies received by the bureau after the position to which they refer has been filled will not be forwarded, and will be held by the bureau for one month only.

OPPORTUNITIES

EXPERIENCED DESIGNERS (10) for electric power plants and transformers, and substations. Men about 30 years of age. Application by letter. Salary not stated. Location, New York City. R-1389.

EXPERIENCED WATER TURBINE DESIGNER. Application by letter. Salary not stated. Location, N. Y. C. R-662.

TRUCK MANUFACTURER is interested in securing for development mechanical or electrical engineering graduates Class 1923 for a brief apprenticeship through our plant to train them for engineering, production, service or sales department. Application by letter. Salary not stated. Location, Pa. R-1208.

ASSISTANT SUPERINTENDENT of power for textile plant in India; unmarried, college graduate, age 27-31 years, good health and habits. Electrical training necessary. Power plant and all transmission, including telephone, fire alarm, and usual mill equipment, is American machinery. Applicant should give qualifications and experience fully. 3 years' contract. Application by letter. Salary not stated. Location, India. R-1209.

CHIEF ENGINEER for steam plant, 4500 kw. for textile mill in India; water tube boiler, G. E. turbines, and all American equipment and electric transmission. Must have good experience, health and habits, and be not over 35 years old. Reply should give qualifications and experience fully. 3 years' contract. Application by letter. Salary not stated. Location, India. R-1210.

ASSISTANT PROFESSOR OF ELECTRICAL ENGINEERING. Duties of the position are the teaching of general Electrical Engineering subjects, including electrical design and communication engineering. Graduate work and some experience either in practical engineering or in teaching engineering subjects. Application by letter. Salary not stated. Location, Arkansas. R-1211.

MASTER MECHANIC OR ENGINEER with experience in oil fields to take charge of hydraulic caission pulling machinery, for extracting caissions. Application by letter. Salary not stated. Location, Texas. R-1249.

GENERAL MANAGER for hydraulic caission pulling machinery to take care of financial and job securing end of business. Application by letter. Salary not stated. Location, Texas. R-1250.

MANAGER for high-tension insulation department, experienced in manufacturing insulators (power line work), familiar with machinery and clays. 25-30 years old. Application by letter. Salary not stated. Location not stated. R-1257.

INSTRUCTOR for employes, classes in organized educational department of a large electric utility corporation. Must be Electrical Engineering graduate with experience in teaching and in an operating company desirable. Write full particulars and state salary acceptable for first year, beginning not later than August 1st. Also enclose kodak photograph. Application by letter. Location, Ill. R-1264.

INSTRUCTOR for employes' classes in organized educational department of a large electric utility corporation, also having gas properties. Must be a technical graduate with experience in teaching and in operating company. Principal classes: Manufacture and Distribution of Gas and Steam Engineering. Write full particulars and state salary acceptable for first year, beginning not later than August 1st. Also enclose kodak photograph. Application by letter. Location, Ill. R-1265.

GRADUATE ELECTRICAL OR MECHANICAL ENGINEER to be trained as inspector for fire insurance company. Men from 1-2 years out of college preferred. Application by letter. Salary not stated. Location, New England. R-1266.

EXPERIENCED MECHANICAL ENGINEER, 30-40 years of age, for service in West Indies. Practical experience with sugar mill machinery and power plant operation. Knowledge of Spanish desirable. Application by letter. Salary not stated. E-1276.

RECENT ELECTRICAL ENGINEERING GRADUATE, to go through a year's course in a factory manufacturing carbon specialties, preparatory to sales work. Application by letter. Salary not stated. Location, Ohio. R-1289.

ELECTRICAL ENGINEER having had 1-2 years' post graduate study and at least 10 years' experience of which at least 3 years must have been in teaching, to fill position of Associate Professor of E. E. Application by letter. Salary not stated. Location, Iowa. R-1298.

DESIGNING DRAFTSMAN with experience on intricate mechanism and instruments. Application by letter. Salary not stated. Location, not stated. R-1308.

ELECTRICAL ENGINEER, experienced in switchboard layouts for power stations, substations. Should have experience in design of high-tension transmission line and outdoor substations. Application by letter, stating age, experience, married or single, technical education and salary expected. Location, New York City. R-1326.

RECENT GRADUATE ELECTRICAL ENGINEER to teach radio engineering. Application by letter. Salary not stated. Location, Ga. R-1329.

INSTRUCTOR to teach mechanical laboratory, elementary engines and boilers, and gas engines. Must be technical graduate. Some experience desirable. Term beginning in September. Application by letter. Salary not stated. Location, South. Salary $1500 for nine months. R-1323.

RECENT GRADUATE to teach mathematics. Application by letter. Salary not stated. Location, Ga. R-1330.

MEN who are qualified draftsmen and designers in electric generating and substation equipment installations. Must be thoroughly familiar with layouts of switchboard, conduit, remote control, and d-c. and a-c. apparatus. Should have at least 2 years' practical experience in this class of design. Application by letter. Salary not stated. Location, New York City. R-1334.

RECENT GRADUATE to do research work in connection with soap and alkali compounds, and to make experimental tests for sales department. Application by letter. Salary not stated. Location, New York City. R-1340.

EDITORIAL ASSISTANT, college graduate with experience in the preparation of engineering reports, bulletins, or publications, or in an editorial office of a publisher of scientific books or magazines; must have a knowledge of English composition and of one or more foreign languages, to enable him to edit and compile data from foreign publications. Application by letter. Salary not stated. Location, Ohio. R-1348.

RECENT GRADUATES to go through training course in factory, manufacturing electric fixtures, preparatory to more responsible position. Application by letter. Salary not stated. Location, Conn. R-1350.

PATENT SPECIFICATION WRITER, Engineer or Technical Graduate, with patent law experience of 2 years. Application by letter. Salary not stated. Location, Ohio. R-1355.

ESTIMATOR, with heating and ventilating experience in contracting and engineering fields. Application by letter. Salary not stated. Location, New York City. R-1361.

SALESMAN for company manufacturing ornamental iron work and light structural steel work. Must know building trade. Application in person. Salary not stated. Location, New York City. R-1363.

JUNIOR, SENIOR OR GRADUATE in Mechanical Engineering, to start in drawing room of small but growing concern, manufacturing automatic combustion control equipment for steam boilers of power plant size. Position will lead to advancement and give opportunity for experience with combustion of many fuses and the operation of modern types of stokers. Present installations number over 200 in Mid-West and Eastern States. Man with practical operating experience preferred. Application by letter. Salary not stated. Location, Pa. R-1374.

SUPERINTENDENT to organize street gang and take charge of asphalt plant for city paving. Highway and street asphalt experience essential. Application by letter. Salary not stated. Location, Mass. R-1382.

SALESMAN industrial Kerosene engines, for Eastern New York, Mass. and Conn. territory. Man familiar with contractors' trade. Salary, commission, and expenses. Application by letter. R-1388.

EXPERIENCED DESIGNERS (10) for electric power plants and transformers, and substations. Men about 30 years of age. Application, by letter. Salary not stated. Location, New York City. R-1389.

ENGINEER, experienced in dryer machinery, familiar with heating problems, to do estimating on insulation work, and to assist in sales and installation work. Application by letter. Salary not stated. Location, New York City. R-1397.

INSTRUCTOR with one years' teaching experience, for Department of Electrical Engineering. Application by letter. Salary not stated. Location, Middle West. R-1400.

INSTRUCTOR for Department of Electrical Engineering. Application by letter. Salary not stated. Location, Middle West. R-1401.

POWER SALES ENGINEER for progressive central station in excellent field. Application by letter. Salary not stated. Location, New England. R-1402.

MECHANICAL ENGINEER, American, between 30-40 years of age, of pleasing appearance and personality; with an ingenious or inventive natural aptitude and considerable experience in practical designing work, to do development and designing work of mechanical equipment in connection with a Department in charge of experimental and research work, in connection with the chemical processes used in the refining of petroleum. Application by letter. Salary not stated. Location, New Jersey. R-1403.

SALES ENGINEERS, young single men for positions as sales and service engineers, calling on Superintendents, Managers, Engineers, Chemists and Metallurgists, for manufacturers of well known high grade automatic electrical and temperature equipment, extensively used in factories, power plants, chemical and industrial works. Knowledge of physics and elementary electricity required. Graduates of technical schools preferred. Candidates must be free to travel in the great manufacturing and industrial districts. Young men good address and ability to talk convincingly to engineers, wanted, but no previous experience demanded. Write describing education, earning experience, if any, and stating age, salary desired. Location, New York City. R-1406.

SALESMAN, experienced on pneumatic mat chinery. Application by letter. Salary nostated. Location, traveling. R-1412.

EXPERIENCED DIE DESIGNER with technical knowledge and practical experience in the drawing and stamping of metals. Must be competent to take charge of entire design on small parts of a complicated nature. Must have manufacturing ability in addition to engineering and designing experience. Application by letter. Salary not stated. Location, Michigan. R-1414.

RECENT GRADUATES, M. E., E. E. and C. E., for drafting room, with Consulting Engineer. Application, by letter. Salary not stated. Location, New York City. R-1405.

MECHANICAL ENGINEER to take charge of the entire mechanical end of a business, including maintenance, installations, equipment specifications, design and power plant, etc. Application by letter. Salary not stated. Location, Pa. R-1416.

RECENT GRADUATE ELECTRICAL ENGINEER, must have good personality. Application by letter. Salary not stated. Location, New York City. R-1417.

RECENT GRADUATE to do research work in connection with heating problems. Application by letter. Salary not stated. Location, New York City. R-1418.

ELECTRIC DISTRIBUTION ENGINEER, with experience in over head lines. Application by letter. Salary not stated. Location, Central America. R-1421.

MECHANICAL ENGINEER with operating and maintenance experience in large industries. Man between 30-40 years of age. Application by letter. Salary not stated. Location, New York State. R-1426.

SALES ENGINEER 28-40 years of age, with considerable sales experience to sell paints and hardware to manufacturers. Application by letter. Salary not stated. Location, traveling, Eastern States. R-1430.

SALES ENGINEER, young Civil Engineer, under 25 years of age, to be trained in sales work. Application by letter. Salary not stated. Location, New York City. R-1432.

RECENT ELECTRICAL ENGINEER to do engineering and sales work, in connection with small motors. Application in person. Salary not stated. Location, New York City. R-1434.

PLANT SUPERINTENDENT with experience in Electro Metallic Deposition, by what is known as the Galvano process. Application by letter. Salary not stated. Location, New York State. R-1435.

HIGH-GRADE, graduate, technical, automotive engineer, with vision and at least ten years' actual American or European experience in the automobile line, who has either invented or produced practical outstanding developments in the automobile industry. Experience on motor work is essential on chassis and body work desirable but not absolutely necessary. Applicants must definitely state education, complete experience, race, present and previous employer, salary earned and expected. Good future to the right man. Application by letter. Location, Middle West. R-1436.

TIME STUDY SUPERVISOR AND SHOP ENGINEER, in charge of all routing, standardization of machinery tools and fixtures, machine methods. Application by letter. Salary not stated. Location, Ohio. R-1438.

CIVIL ENGINEER familiar with design, construction, maintenance and operation of hydroelectric plants, also with all phases of the collection and interpretation of stream flow data, as well as making an interpretation of topographic maps required in the study of water power problems. Application by letter. Salary not stated. Location, Tenn. R-1442.

YOUNG MAN acquainted with theatres and electrical supply houses, wanted to handle "Colorine." Chance for investment after investigation. Application by letter. Salary not stated. Location, New Jersey. R-1444.

SAFETY ENGINEER in compensation department of an insurance department. Application by letter. Salary not stated. Location, New York City. R-1446.

MECHANICAL ENGINEER, 30-40 years having had foundry and machine shop experience to act as assistant to general manager of a wire mill machinery company in coordinating the work of the different departments. Application by letter. Salary not stated. Location, Illinois. R-1450.

MAN to take charge of Transformer Assembly Dept. Must thoroughly understand high-voltage apparatus and the assembly of such apparatus in large units. Application by letter. Salary not stated. Location, Canada. R-1451.

SUPERINTENDENT for burlap factory in Central America. Preferably married, over 30. Must be able to speak Spanish, handle Latin labor. Location in town of 40,000 people. Location healthy, not low, very few foreigners. Contract for several years. Must be experienced and able to repair machinery. Application by letter only giving full details. Not open immediately. Location, Central America. Salary not stated. R-1452.

RECENT GRADUATES (2) 1923 to do inspection work on underground conduits and cables. Application by letter. Salary not stated. Location, Pa. R-1454.

MECHANICAL ENGINEER between 30-40 years to act as operating superintendent for a cement plant. Experience in manufacture of cement is desirable. Real essentials being ability to handle men and get most out of them, and willingness to follow instructions exactly. Application by letter. Salary not stated. Location, N. Y. State. R-1455.

1923 GRADUATE MECHANICAL ENGINEER for apprentice course leading to sales. Salary \$100 for the first 6 months, \$110 per month the 2nd 6 months and \$130 at the beginning of the 2nd year. Application by letter. Location, not stated. R-1465.

CHIEF DRAFTSMAN in our Engineering Department, familiar with the design and construction of special apparatus and machinery, also with machine shop practise, and capable of putting out drawings in our shop with the necessary information on them, so that the shop is fully informed as to just what is wanted. Application by letter. Salary not stated. Location, New York State. R-1471.

ASSISTANT PROFESSOR IN GENERAL ENGINEERING DRAWING. Must be a graduate of a recognized technical school, with engineering experience. Application by letter. Salary not stated. Location, Illinois. R-1472.

PUMP TESTER WANTED. Man having experience in the testing of centrifugal pumps, steam pumps, and power pumps. Must be thoroughly familiar with modern test floor methods and competent to handle electrical and hydraulic equipment. Application by letter stating age, experience, present salary and salary expected. Location, Michigan. R-1475.

SUPERINTENDENT for a cement plant, having a capacity of about 250 barrels per day. Must be able to take entire charge of plant and capable of checking up chemical analysis of cement when necessary. Application by letter. Salary not stated. Location, Peru. R-1476.

ENGINEER familiar with design of water power development. Application by letter. Salary not stated. Location, New York State. R-1482.

A large central station in New York City, requires the services of a recent technical graduate to assist on general power plant test work and instrument maintenance work. Although the work at first will be quite elementary, it is desired that the applicant should possess a thorough technical knowledge and should also possess initiative, tact, and a pleasing personality in order to be in line for promotion when such an opportunity arrived. Application by letter. Salary noted stated. Location, New York City. R-1485.

RATES ENGINEER with several years experience, preferably on non-ferrous, rolling, or wire mills. Application by letter. Salary not stated. Location, Conn. R-1487.

ENGINEER with automotive manufacturing experience to do sales work, calling on manufacturers, for an oil company. Application by letter. Salary not stated. Location, West. R-1491.

SALES ENGINEER, preferably one who has called on the electrical and hardware trade, to travel for company manufacturing electrical wiring devices. Application by letter. Salary not stated. Location, New Jersey. R-1492.

ELECTRICAL, MECHANICAL OR CIVIL ENGINEER, who has had 5-6 years' practical experience preferably in public utility operation and construction for accident investigation and prevention work. Also should have gas plant experience. Application by letter stating age, education and experience. Salary not stated. Location, traveling about one-half of time. R-1493.

SUPERINTENDENT of a malleable iron foundry. Must have a complete knowledge of all departments of foundry work, and ability to handle 300 men, mostly Americans. Must have had several years practical experience in executive management of malleable iron foundry. Application by letter. Salary not stated. Location, New England. R-1490.

MANUFACTURING SUPERINTENDENT thoroughly experienced in manufacture of high-frequency apparatus, such as radio appliances. Must be college graduate in Electrical Engineering. Permanent and good future. Application by letter. Salary not stated. Location, near Chicago. R-1525.

INSTRUCTOR to teach General Engineering at college in Department of Civil Engineering. Desire young, energetic man with preferably some practical and teaching experience. Must be

able to teach Engineering Drawing, Descriptive Geometry, Graphic Statics, Elementary Engineering, including Civil, Electrical and Mechanical and Preparatory Physics. Application by letter. Salary not stated. Location, South. R-1526.

SAFETY ENGINEER who is a graduate of some recognized technical school, and who has had five or six years' experience in electrical engineering, particularly in public utility plants. Application by letter. Salary not stated. Location, New York City. R-1531.

DRAFTSMAN over 21 years of age for electrical power switchboard-drafting work, who has had at least four or five years' experience and capable along that line in every detail. R-1536.

ELECTRICAL power hoist draftsman over twenty-one years of age who is capable to design, and must have at least three years' practical experience. R-1537.

GRADUATES of good technical schools to take positions with a large manufacturing company on switching and control apparatus. Good opportunities for advancement. Openings for both recent graduates and experienced designers. Application by letter. Salary not stated. Location, Pa. R-1552.

YOUNG MAN of good address, sufficiently well versed technically, to figure engine sizes when given proper conditions, and to know what conditions are necessary to have in order to determine the size and type best suited for the work. This will, of course, necessitate some knowledge of electrical apparatus, and ability to looking up new work, to work on a drawing account and commission. Application by letter. Headquarters, Pa. R-1551.

ELECTRICAL ENGINEER to teach Junior courses in Electrical measures and dynamo laboratory, and addition classroom work to be determined by qualification of applicant. Application by letter. Salary not stated. Location, within 100 miles of New York City. R-1602.

INSTRUCTOR one-half time teaching fellowship in Electrical Engineering. Applicant should either be recent graduate in Electrical Engineering or graduate with thorough training in physics, desiring to pursue Electrical Engineering studies. Application by letter. Salary $800. Location, within 100 miles of New York City. R-1603.

MEN AVAILABLE

ELECTRICAL ENGINEER with eight years' engineering and executive experience and five years' sales and commercial experience, desires position. Technical graduate. Unusual experience in public utility field in executive capacities. Has record above average and is hard worker. Married. Age 35. At present in business for himself. E-4337.

LABORATORY ENGINEER: To take charge of electrical laboratory or department of same. Experienced in all classes of electrical testing connected with power development and distribution. Specialist in instruments, meters and precise methods of measurements. Member A. I. E. E. E-4338.

YOUNG ENGINEER with four years' experience in the development of new apparatus and high-voltage design desires to become connected with a consulting firm, or with a large operating company. Only positions with possibilities of permanence and chance for advancement will be considered. E-4339.

HYDROELECTRIC ENGINEER. Investigations, engineering, construction, management. Long experience in Spanish American countries. E-4340.

ELECTRICAL ENGINEER, graduate of one technical school and 3 years at another, desires a position in Greater New York. Eleven years' experience with four of the largest firms of this kind in New York. American, married, age 32. Member A. I. E. E. Can start immediately. E-4341.

TECHNICAL GRADUATE, B. S. in engineering. Age 26, single, desires to connect with a public utility or engineering company doing electrical construction or operating work. Has had 1½ years' experience in power house construction and maintenance, also three months in distribution engineering department and some mine electrical construction. Has handled men on the above work. E-4342.

ELECTRICAL ENGINEER, 32 years of age, University graduate, 11 years' experience including G. E. shop testing course, construction and operation of steam and hydro plants and a thorough knowledge of the design of power stations, substations and electrical systems. At present with large public utility in responsible position. E-4343.

ELECTRICAL ENGINEER '22 and B. S. '21 desires to change his position. Has been working for one and one half years at general engineering; nine months as a development man in radio. For past half year has been employed in design, testing, cost estimating supervision and a little drafting. Would like to connect with a responsible concern in or near New York City. Starting salary $1800. E-4344.

ELECTRICAL ENGINEER, age 28, married 10 years' practical experience on construction operation and maintenance of central and isolated plants also small amount of street railway experience, and one year teaching. Available immediately. E-4345.

ELECTRICAL ENGINEER, age 26, graduate, four years' varied experience in design and construction, mechanical and electrical, wants opportunity to develop into sales engineer, prefer N. Y. City and vicinity. E-4346.

ENGINEER, electrical and mechanical, construction, operation and maintenance. 15 years' experience in a large establishment involving supervision of construction, operation and maintenance of power plants, substation a-c. and d-c. distributing systems, compressed air, steam, water, etc.; lighting, heating, elevators, motors, pumps and other building equipment; supervision of contract work, inspections, technical correspondence. Location, New York City and vicinity. E-4347.

YOUNG ELECTRICAL ENGINEER receiving B. S. in E. E. degree in June 1923 desires a permanent position in engineering department of street railway corporation or with an electrified railroad. Has had practical experience in both organizations. Available July 1st. E-4348.

MANAGER or SUPERINTENDENT railway, light and power properties, technical, successful organizer and tactful in public relations and very resourceful in rehabilitating properties. Available in 30 days. E-4349.

EXPERT on small motors, technically trained, eight years' practical experience, all forms of fan and small motor test and experimental work, including high-voltage and specialized apparatus. Good references from reputable firms. Salary only. Available at once, New York or New Jersey preferred. E-4350.

YOUNG MAN, 28 desires position as assistant to an executive, where chance for advancement is good. First class references, good education. Employed at present but available on short notice. Location near or in New York City. E-4351.

POSITION OF RESPONSIBILITY DESIRED by electrical and mechanical engineer, 33 years old, married. Qualified for executive position, with 13 years' executive and actual experience in charge of operation of medium large steam and electrical apparatus, underground and overhead distribution systems and high-tension substations. Technical graduate, G. E. Test-G. E. Salesman, engineer, officer during war. Capable of assuming responsibility, good management, utility accounting and boiler room economy. At present employed, minimum salary $3600. E-4352.

GRADUATE ELECTRICAL ENGINEER with several years power plant supervision experience, capable of working at all phases of the industry, is planning to go to South America on his own responsibility, desires position or opportunity to represent manufacturing or construction firm. Salary no consideration. Fair knowledge of Spanish. E-4353.

POSITION WANTED with power or central station company in charge of distribution and contracting business in small town. 15 years' experience high-tension and textile engineering, estimating and supervision. Age 35, graduate E. E., Associate A. I. E. E. and I. E. S. E-4354.

A TECHNICAL GRADUATE age 25 desires position with well established electrical contractor or consulting engineer. At present employed on a-c-d-c. changeovers. Knowledge of accountancy. Two years test gang boss, Western Electric. Associate A. I. E. E. E-4355.

ELECTRICAL ENGINEER, B. S. degree, age 26, single 2½ years' practical experience with public utility, 1 year telephone machine switching, 2½ selling and 2 years radio research work, desires connection with well established electrical concern. At present employed but available on reasonable notice. E-4356.

ELECTRICAL ENGINEER, age 25, college graduate. Desires position as assistant to chief engineer or superintendent of power system. 2½ years' experience in the operation and maintenance of hydroelectric plants. Available September 1st. E-4357.

ELECTRICAL ENGINEER, technical graduate with additional training in railroad work. Eight years' experience on electrical design and supervision of construction on large industrial layouts and power plants. Desires opportunity for permanent position with an electric railway, public utility or consulting engineer. E-4358.

ELECTRICAL ENGINEER, technical graduate and graduate La Salle accounting course, age 29, married, two years' general testing experience and six years' office and field work checking cost of installing electric equipment. Desires permanent connection with good future. Can furnish references. Location Northeastern States. E-4359.

ENGINEERING EXECUTIVE with broad experience in design and application of electrical machinery, organization, production, cost accounting and analysis, desires position along similar lines. Available on short notice. E-4360.

ELECTRICAL ENGINEER experienced in design and construction of hydroelectric plants, substations, transmission and distribution systems mechanical and electrical drafting, extending over a period of 20 years. M. E. graduate, Associate A. I. E. E. Age 41. Employed at present, but must locate in southern California. Available September 1st. E-4361.

ELECTRICAL ENGINEER, age 23, married, 1921 graduate, Associate A. I. E. E., two years' teaching and graduate work at a large technical school. Desires a position as instructor in electrical engineering or physics. E-4362.

MAN 27, technical graduate, 5 years' electrical and mechanical experience with manufacturing company making highly technical instruments, at present and for the past 14 months in charge of their experimental laboratory, desires change to job in New York City or immediate vicinity offering good future. E-4363.

ELECTRICAL ENGINEER, Technical graduate, 1918, age 27, married, desires permanent connection with railway system planning electrification or already electrified where opportunity is open for learning electric railroading in all branches particularly administration. Interested especially in maintenance and operating costs. Previous experience includes indoor and outdoor substation construction work, and handling and testing of all classes of electrical machinery. Willing to travel a few years if necessary. Salary dependent upon location. Location preferably in U. S. Available on reasonable notice. E-4364.

METER SUPERINTENDENT OR ENGINEER, experienced on Westinghouse, General Electric, Esterline and other demand and graphic meters, and integrating meters, and tests on consumers apparatus who by previous work on construction in large plants and as contractor also appreciates the consumers and contractors prob-

lems and can work with them. Now employed on such work by utility. A good judge of men. Graduate of Cornell, M. E. 1913. Also qualified for employment as engineer by industrial plant. E-4365.

ELECTRICAL ENGINEER B. S. degree, age 32, single, apprentice course of large electrical manufacturing corporation. Two years sales engineering, one year experience as engineering executive. Successful leader of men. At present employed but desires change to either sales or executive position. Hard work and responsibilities welcomed. Correspondence solicited. Salary open. E-4366.

FIELD ENGINEER, seven years of extraordinary experience in installation and designing of industrial and power plants. All types, all systems. Good initiative, marked ability in handling men, expert in automatic control. Location immaterial, available on short notice. E-4367.

GRADUATE ELECTRICAL ENGINEER. Associate A. I. E. E., six years' experience in central station engineering, expecially distribution and transmission. Desire responsible position with progressive central station. Now employed but available on two weeks notice. Excellent references. E-4368.

YOUNG MAN, single age 26, desires position, preferably in south or middle-west, either in operation or construction work. Experienced in operation and maintenance of boilers, engines and turbines in medium sizes. Three years' experience as chief operator of large high-tenison substation and one year as plant engineer of industrial concern. Thoroughly experienced on all kinds of power houses, instruments and electric meters, relays and switchboard apparatus. Technical education and a close student of power activities. A position is especially desired in which further study and development will be encouraged. Available on short notice. E-4369.

ELECTRICAL ENGINEER, technical graduate, with both General Electric and Westinghouse office and field experience, and practical experience with railway, lighting and power companies on engineering, construction and operating; also with firm of consulting and constructing engineers on estimating, appraisal and supervision. Character and ability references of the best. At present employed but available on reasonable notice. E-4370.

COMMERCIAL ENGINEER graduate mechanical and electrical engineer, age 30. Thoroughly reliable and progressive. Two years' G. E. test. Six years' experience covering commercial work, sales, construction, maintenance and superintendent of factory. Desires association with a manufacturing engineer or allied concern where he can have a financial interest of about $7500. Chicago or vicinity preferred but not essential. E-4371.

WORKS ENGINEER OR ASSISTANT WORKS ENGINEER, desires position in fairly large plant, have had technical and in addition six years' electrical construction and maintenance experience; and six years' strictly mechanical experience, steam engines, turbines, and boilers. Also hold and had eleven months' service on marine engineers license. Age 33. Available on short notice. E-4372.

DEVELOPMENT ENGINEER M. E. Cornell, Associate A. I. E. E. Thirteen years investigation, design and manufacture with large and small organization, six years' installation mostly for United States and foreign governments, five years sales. Experienced in telegraph, telephone and submarine apparatus and construction, cable manufacturing and other heavy machinery, automobiles and trucks. Age 46, married, excellent health. E-4373.

ELECTRICAL ENGINEER three years' technical training and two years' experience wishes position with some concern engaged in hydroelectric power development. Experienced in designing and development work with large concern manufacturing automatic electrical equipment. Associate A. I. E. E. Age 23 years. Location immaterial. At present in New York City. Available September 1st. E-4374.

EDITORIAL POSITION or one in advertising field wanted by graduate engineer. Age 26. Sales experience, experience on editing house publications. Considerable experience in practical engineering. E-4375.

ELECTRICAL AND MECHANICAL ENGINEER age 36, married, 15 years' experience in the design, construction and operation of power plants and water works desires position as superintendent of one of the above named or combination of both, temporarily employed at present but will be through present job July 1st. Will go anywhere. E-4376.

ELECTRICAL ENGINEER, technical graduate, age 36, married, having 12 years' experience in design and construction of power plants, transmission and distribution systems, and general engineering work including public utility operation in executive capacity, desires position of a permanent nature with public utility or engineering firm. E-4377.

ASSISTANT TO EXECUTIVE (electrical) experienced on power house and substation design, specifications, buying. Wide experience both public service and industrial. Salary open. E-4378.

ELECTRICAL ENGINEER, age 26, single, college and Navy engineering school graduate, one year's steam and three years electrical public utility experience, as technical investigator. Desires position with engineering or consulting firm, or technical publication where his training will be of mutual benefit. E-4379.

INTELLIGENT TECHNICAL GRADUATE in electrical engineering (1917) with 15 months G. E. test, 9 months in the Navy steam engineering school for officers, and 4 years in special engineering work, desires responsible position with opportunity for advancement in any line where previous experience will be useful. Has had considerable experience in technical library work and as an executive. Excellent character and ability references. Employed at present but available on reasonable notice. E-4380.

ELECTRICAL ENGINEER, technical graduate. Age 29. Seven years' experience in construction and layout of transformer stations, transmission lines, substations, power house equipment and motor drives of various types. Experienced in both a-c. and d-c. equipment. Desires a connection with a future for an energetic man. E-4381.

GRADUATE, age 26. Thorough training theoretical and practical, in generation and transmission engineering. 5 years' experience on design and construction of small hydroelectric plants, indoor and outdoor substations up to 115 kv., switchboard design, automatic substations and transmission line work. Wishes to locate in West. Available there early in August. E-4382.

PROFESSOR OF ELECTRICAL ENGINEERING S. M. E. E. from M. I. T. Age 30. 6 years' teaching experience in addition to several years of practical work. Desires teaching position with university or college. Available immediately. Complete details furnished on request. E-4383.

MEMBERSHIP — Applications, Elections, Transfers, Etc.

ASSOCIATES ELECTED JUNE 27, 1923

ADAMS, BERNERD WILLIAM, Instructor, Mechanical Engineering, University of Arkansas, Fayetteville, Ark.; for mail, Hamilton, Mo.

AKASAKA, TOSHI, Managing Director, Annaka Electric Works, Ltd., 1866 Shimo-Shibuya, Tokyo, Japan.

ALBERT, WILLIAM ASBJORNSEN, Asst. Electrical Engineer, West Penn Power Co., 14 Wood St., Pittsburgh, Pa.

ALDEN, DEAN WATSON, Student Engineer, Blackstone Valley Gas & Electric Co., Woonsocket, R. I.

ALLEN, CLAYTON MOSES, Junior Electrical Engineer, Bureau of Power & Light, City of Los Angeles, 207 S. Broadway, Los Angeles, Calif.

ALLEN, RALPH H., Electrical Designer, Brooklyn Edison Co., 40 Flatbush Ave. Ext., Brooklyn, N. Y.; res., Ramsey, N. J.

ANCKERS, NILS JOHN HERMAN, Radio Engineer, Radio Corp. of America, Riverhead, N. Y.

*ANNAPPA, M. L., Student, General Electric Co., Schenectady, N. Y.

ARMSTRONG, GUY OSWALD, Central Station Operator, Spanish River Pulp & Paper Mills, Smoky Falls, Ont., Can.

ARNOLD, WALTER HENRY, Meter Tester, Bureau of Power & Light, City of Los Angeles, Los Angeles, Calif.

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WEATHERSPOON, EDWARD HOWERTON, Electrical Engineer, Charles Cory & Son, Inc., 183 Varick St., New York, N. Y.

WEEKS, GEORGE McDOUGALL, Jr., Engineer, New York Telephone Co., 104 Broad St., New York, N. Y.

WEINFELD, ABRAHAM BENJAMIN, President Electric Power Equipment Co., 51 E. Chestnut St., Columbus, Ohio.

WELKER, VERNE IRVING, Electrical Power Engineer, The Northwest Paper Co., Mill Office, Cloquet, Minn.

WELSFORD, BERTRAND WILLIAM HAMILTON, U. S. Veterans' Bureau Trainee, Drexel Institute, 32nd & Chestnut Sts., Philadelphia, Pa.

WHEELER, WILLOUGHBY SHAW, Student, Armature Shop, Electric Construction Co., Bushbury; res., Wolverhampton, Eng.

WHITAKER, JOHN CECIL, Engineering Assistant, Bell Telephone Co. of Pennsylvania, 261 N. Broad St., Philadelphia; res., Glenside, Pa.

*WHITTAKER, ALAN D., Jr., Lieutenant U. S. A., Fort Winfield Scott, Calif.

WILDER, LAURENCE R., Vice-President, Scintilla Magneto Co., Inc., 225 W. 57th St., New York, N. Y.

WILLIAMSON, EUGENE JESSE, Student Engineer, Testing Dept., General Electric Co., 23 N. Ferry St., Schenectady, N. Y.

WILSON, JOHN EDMUND, Switchgear Superintendent, Municipal Electricity Dept., Shanghai, China.

WINTERBOTTOM, WILLIAM A., Traffic Engineer, Radio Corp. of America, 64 Broad St., New York, N. Y.

ZABEL, Erich O., Construction Foreman, Alexandria Light & Power Co., Alexandria, Va.

ZANT, LAWRENCE NOEL, Sales Engineer, Pacific States Electric Co., 570-1st Ave. South, Seattle, Wash.

ZSIBA, ALEXANDER, Jr., Supervisor of Circuit Analysis Engineers, Western Electric Co., Inc., 268 W. 36th St., New York, N. Y.

Total 270.

*Formerly Enrolled Students.

ASSOCIATES REELECTED JUNE 27, 1923

CLARKE, FRED, General Installation Engineer, Western Electric Co., Inc., 195 Broadway, New York, N. Y.; res., Leonia, N. J.

McCARTHY, JOSEPH B., Electrical Superintendent, International Nickle Co., Copper Cliff, Ont., Can.

PHILLIPS, IRVING W., Electrical Engineer, Perry & Whipple, 513 Hospital Trust Bldg., Providence, R. I.

PROCTER, JOSEPH HAROLD, Patent Attorney, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

WILLS, GEORGE M., Asst. General Superintendent, The Southern Sierras Power Co., 771-8th St., Riverside, Calif.

ASSOCIATES REINSTATED JUNE 27, 1923

CASSIDY, GEORGE EMMES, Engineer, Power & Mining Engg. Dept., General Electric Co., Schenectady, N. Y.

LIVINGSTON, ROBERT R., Professional Engineer, 2 Rector St., New York, N. Y.

STANLEY, JOHN LAWRENCE, Consulting Engineer, Hotel Aspinwall, Lenox, Mass.

MEMBERS ELECTED JUNE 27, 1923

BURLEIGH, DAVID PAUL, District Meter Specialist, General Electric Co., 120 Broadway, New York, N. Y.

CATON, EDWIN VICTOR, Electrical Engineer, Winnipeg Electric Railway Co., Winnipeg, Man., Can.

CURTIS, CLAUDE CLAYTON, Manager, Cape Breton Electric Co., Ltd., Sydney, N. S., Can.

HEARN, RICHARD LANKASTER, Asst. Chief Engineer, Washington Water Power Co., Spokane, Wash.

HIRSCH, JOHN GEORGE, Principal Asst. Engineer, Benham Engineering Co., Gumbel Bldg., Kansas City, Mo.

LANE, FRANCIS HOWARD, Manager, Engineering & Construction, Byllesby Engineering & Management Corp., 208 S. La Salle St., Chicago, Ill.

MASURY, ALFRED FELLOWS, Chief Engineer, Vice-President and Director, International Motor Co., 252 W. 64th St., New York, N. Y.

McCORMICK, CHARLES M., Asst. Professor, Electrical Engineering Dept., University of Colorado, Boulder, Colo.

POTTER, FRANK R., Electrical Contractor, 1982 Railway Exchange Bldg., St. Louis, Mo.

SMITH, PAUL H., Asst. Purchasing Agent, Brooklyn Edison Co., 360 Pearl St., Brooklyn, N. Y.

SPEER, JAMES WILSON, Chief Electrical Engineer, The Wellman-Seaver-Morgan Co., 7000 Central Ave., Cleveland, Ohio.

WEAGANT, ROY ALEXANDER, Consulting Engineer, Radio Corp. of America, 66 Broad St., New York, N. Y.

WIGGIN, STANLEY, Dist. Superintendent, Consumers Power Co., Alma; res., Detroit, Mich.

WULFING, HARRY E., Engineer, Inside Plant Division, Commonwealth Edison Co., 72 W. Adams St., Chicago, Ill.

FELLOW ELECTED JUNE 27, 1923

STANLEY, ROY MORGAN, Electrical Engineer Byllesby Engineering & Management Corp., 208 S. La Salle St., Chicago, Ill.

TRANSFERRED TO GRADE OF FELLOW JUNE 27, 1923

GOODWIN, HAROLD, Jr., Engineering Staff, Sanderson & Porter, New York, N. Y.

KLAUBER, LAURENCE M., Vice-President & General Superintendent, San Diego Consolidated Gas & Electric Co., San Diego, Calif.

TRANSFERRED TO GRADE OF MEMBER JUNE 27, 1923

AHEARN, WILLIAM H., Principal Assistant to John A. Beeler, New York, N. Y.

BELT, THOMAS A. E., Engineer, Northwest Coast District, General Electric Co., Portland, Ore.

CLOUD, FREDERICK W., Engineer & Contractor, Los Angeles, Calif.

FEY, WILLIAM L., Assistant Engineer, Board of Commissioners of the Port of New Orleans, New Orleans, La.

FOWLER, T. R., Assistant Chief Engineer, Kinloch Telephone Co., St. Louis, Mo.

FULLER, FLOID M., Electrical Engineer, United Service Corp., Scranton, Pa.

GASKILL, JOSEPH F., Power Engineer, Philadelphia Electric Co., Philadelphia, Pa.

GRATWICKE, WALTER, Engineer, British Aluminum Co. Ltd., New York, N. Y.

KELLEY, WALTER F., Engineer, Apparatus Design Dept., Western Electric Co., New York, N. Y.

KETCHAM, H. H., Head of Electric Dept., Extension Division, United Y. M. C. A. Schools, New York, N. Y.

KNIGHT, EDWARD D., Vice-President & Chief Engineer, Virginian Electric Inc., Charleston, W. Va.

KOOPMAN, THOMAS O., General Superintendent, Electrical & Mechanical Dept., Submarine Boat Corp., Newark, N. J.

LANDGRAF, THEODORE H., Division Plant Engineer, Southern Bell Tel. & Tel. Co., Atlanta, Ga.

LESCARBOURA, A. C. Managing Editor, Scientific American, New York, N. Y.

MACY, HENRY D., Field Engineer, Westinghouse Electric & Mfg. Co., New York, N. Y.

MIX, MARTIN I., Assistant Superintendent of Pressure, Peoples Gas, Light & Coke Co., Chicago, Ill.

MORRIS, GLEN S., Research Engineer, Kansas City Power & Light Co., Kansas City, Mo.

NIXON, HENRY, Deputy Commissioner of Electricity, City of Chicago, Chicago, Ill.

RATHBUN, HARRY J., Vice-President & Treasurer, Colin B. Kennedy Corp., St. Louis, Mo.

RATHGEB, CHARLES C., Superintendent of Construction, L. K. Comstock & Co., New York, N. Y.

REINHOLDT, PAUL H., Electrical Engineer, Iowa Light, Heat & Power Co., and Consumers Electric Co., Carroll, Ia.

VICTORY, THORNTON M., Electrical Engineer, Havana Electric Railway, Light & Power Co., Havana, Cuba.

WINDERS, FRANK R., Assistant Engineer, National Electric Light Association, New York, N. Y.

WOHLGEMUTH, M. J., Switchboard Engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

RECOMMENDED FOR TRANSFER

The Board of Examiners, at its meeting held June 15, recommended the following members of the Institute for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the Secretary.

To Grade of Fellow

BOZELL, HAROLD V., Editor, *Electrical World*, New York, N. Y.

MANSON, GEORGE K., Chief Engineer, New England Telephone & Telegraph Co., Boston, Mass.

WOODROW, HARRY R., Assistant Electrical Engineer, Brooklyn Edison Co., Brooklyn, N. Y.

To Grade of Member

DENNISON, BOYD C., Associate Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

FERNALD, JOHN M., Engineer, Cutler-Hammer Manufacturing Co., Boston, Mass.

HEUSER, JOHN U., Branch Manager, Cutler-Hammer Manufacturing Co., Chicago, Ill.

JALONACK, HAROLD M., Transformer, Regulator & Lightning Arrester Specialist, General Electric Co., New York, N. Y.

NASH, E. J., Acting General Manager, Butte Electric Railway Co., Butte, Mont.

PEARCE, WALTER R., Chief Engineer, New Brunswick Telephone Co. Ltd., St. John, N. B.

RICHMOND, HAROLD B., Secretary, General Radio Co., Cambridge, Mass.

SPLITSTONE, EDWARD L., Emerson Electric Mfg. Co., St. Louis, Mo.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a higher grade than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before July 31, 1923.

Allen, F. J., Pacific Power & Light Co., Naches, Wash.

Bassett, C. W., Elevator Supplies Co., Hoboken, N. J.

Bailey, R. P., General Electric Co., Kansas City, Mo.

Binford, J. T., The Chesapeake & Potomac Tel. Co., Washington, D. C.

Blake, D. K., General Electric Co., Schenectady, N. Y.

Blakeslee, E. M., Stanford University, Stanford University, Calif.

Bowling, N., Westinghouse Elec. & Mfg. Co., Boston, Mass.

Brower, R. F., New York Edison Co., New York, N. Y.

Brunner, A. F., Brooklyn Edison Co., Brooklyn, N. Y.

Bullen, H. B., Edison Elec. Illuminating Co., Boston, Mass.

Carleton, Fred C., Northwestern Electric Co., Camas, Wash.

Carlsen, F. H., Public Service Electric Co., Hackensack, N. J.

Caulfield, J. S., Brooklyn Edison Co., Brooklyn, N. Y.

Clark, H., Humble Pipe Line Co., Houston, Texas

Clemons, D. R., Dodge's Institute, Valparaiso, Ind.

Collison, G. C., Witherbee Battery Co., Washington, D. C.

Colony, M. P., Milwaukee Elec. Rwy. & Lt. Co., Milwaukee, Wis.

Cox, P. E., Georgia Railway & Power Co., Atlanta, Ga.

Diefenderfer, J. H., East Penn Electric Co., Pottsville, Pa.

Dobbins, W. E., Jr., Capital Electric Co., Atlanta, Ga.

Donahue, J. C., Substation Operator, Takoma, Wash.

Ellis, J. L., Jr., Georgia School of Technology, Atlanta, Ga.

Endicott, T. H., (Member), Green Equipment Corp., Chicago, Ill.

Ferguson, L. W., Killarney Coal Co., Killarney, W. Va.

Fleshler, A. D., Transit Comm. of New York, New York, N. Y.

Forties, R. W., Canadian General Electric Co., Ltd., Queenston, Ontario, Canada

Fuog, A. T., Harvey Electric Co., Chicago, Ill.

Gadkary, S. A., General Electric Co., Inc., Schenectady, N. Y.

Gamble, L. R., Washington Water Power Co., Spokane, Wash.

Garbett, J. H., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

Gersch, A. E., Commonwealth Edison Co., Chicago, Ill.

Graham, V. M., Stromberg-Carlson Tel. Mfg. Co., Rochester, N. Y.

Greenlee, R. P., Commonwealth Edison Co., Chicago, Ill.

Greer, R. C. L., (Member), East Penn Electric Co., Pottsville, Pa.

Harrell, W. E., Bureau of Power & Light, Los Angeles, Calif.

Hays, S. L., The Rapid Electrotype Co., Cincinnati, Ohio

Hayward, C. S., (Member), Alabama Power Co., Muscle Shoals, Ala.

High, S. F., (Member), G. W. Sullivan Electric Co., Cincinnati, Ohio

Hursh, J. I., Sargent & Lundy, Chicago, Ill.

Johnstone, W. S., Erie Railroad, Hornell, N. Y.

Juhnke, E. C., The United Gas Improvement Co., Philadelphia, Pa.

Kenyon, L. A., (Member), Montreal Lt., Ht. & Pr. Comm., Montreal, Quebec

Kerr, S., New York Telephone Co., New York, N. Y.

Kettenring, L. R., University of Washington, Seattle, Wash.
Kist, C. F., Jr., The E. W. Clark Co., Management Corp., Columbus, Ohio
Lapham, E. A., Morganite Brush Co., New York, N. Y.
Leighton, H. D., Minnesota Electric Light & Power Co., Cushing, Okla.
Leonard, W. D., Water, Light & Gas Commission, Ft. Atkinson, Wis.
Levy, D. H., E. W. Tompkins Co., Albany, N. Y.
Lintner, G. U., Jr., U. S. Marine Corp, Marine Flying Field, Quantico, Va.
Lundell, T. A., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Marshall, E., (Member), Great Northern Railway, St. Paul, Minn.
Matthews, C. H., Toledo & Western R. R. Co., Sylvania, Ohio
Matthews, W. R., Washington Water Power Co., Spokane, Wash.
Mayer, F. H., So. California Edison Co., Los Angeles, Calif.
McLaren, W. E., United Fruit Co., Bocas del Toro, Panama, R. P.
Melville, J. H., Dallas Power & Light Co., Dallas, Texas
Metz, C. J., Ohio Bell Tel. Co., Akron, Ohio
Mitchell, H. F., San Joaquin Light & Power Corp., Fresno, Calif.
Morgan, D. T., Beech Bottom Power Co., Power, W. Va.
Parker, W. W., Commonwealth Edison Co., Chicago, Ill.
Parks, M. B., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Parks, M. D., Western Public Service Co., Seottsbluff, Nebr.
Pattinson, G. E., Pacific Gas & Electric Co., Cassel, Calif.
Peterman, W. C., (Member), Western Union Telegraph Co., New York, N. Y.
Petz, A. H., National District Telegraph Co., New York, N. Y.
Reid, H. L., Capital Electric Co., Atlanta, Ga.
Robinson, W. D., Modoc Lumber Co., Aspgrove, Ore.
Rowley, B. E., Edison Electric Appliance Co., Salt Lake City, Utah
Rush, F. M., Radio Corp. of America, Marshall, Calif.
Schaetzle, H. J., Bell Telephone Co. of Pa., Philadelphia, Pa.
Schroetter, E. O., Larkin Co., Inc., Buffalo, N. Y.
Schwebel, A. X., The Atlas Electric & Mfg. Co., Middletown, Ohio.
Scott, R. C., United Gas & Electric Co., Cincinnati, Ohio
Sinnott, C. L., American Can Co., Baltimore, Md.
Smith, J. J., Brooklyn Edison Co., Brooklyn, N. Y.
Stamper, F. H., Brooklyn Edison Co., Brooklyn, N. Y.
Stoll, A. F., Russell & Stoll Co., New York, N. Y.
Towne, R. E., (Member), Municipal Light Dept., Tacoma, Wash.
Trueblood, F. V., Southern California Edison Co., Whittier, Calif.
Trueman, M. C., Canadian Westinghouse Co., Hamilton, Ont., Can.
Tuck, D. H., (Member), Holophane Glass Co., Inc., New York, N. Y.
Tymon, C. P., The United Gas & Improvement Co., Bethlehem, Pa.
Ungerer, H. L., Elevator Supplies Co., Hoboken, N. J.
Vallas, M. H., Tulane University, New Orleans, La.
Walker, E. L., The Williamsburg Power Co., Williamsburg, Va.
Warfield, S. C., (Member), M. O. & W. Engg. Corp., Norton, Va.
Weidner, E. W., Electric Supply & Maintenance Co., Reading, Pa.
Weyandt, C. S., (Member), National Electric Mfg. Co., Pittsburgh, Pa.
Wolff, L. Brunswick-Balke Collender Co., Muskegon, Mich.
Zarth, W. A. F., Stamford Rolling Mills Co., Springdale, Conn.
Total 91

Foreign

Bingham, J. M., Horowhenua Elec. Pr. Board, Levin, N. Z.
Chari, P. V., Public Works Dept., Madras, India
Couzens, D. F., Western Electric Co. Ltd., N. Woolwich, London, E 16, Eng.
Hughes, W. H., Electric Construction Co., Ltd., Wolferhampton, Eng.
Jolley, L. B. W., General Electric Co., Wembley, Eng.
Monk, W. W., Shanghai Water Works Co., Ltd., Shanghai, China.
Orsini, S., Municipal Wks. Div., Dept. of Interior, P. R., Sebastian, P. R.
Pearce, J. G., (Member), Metropolitan-Vickers Co., Trafford Park, Manchester, Eng.
Slack, W. S., International Machinery Co., Antofogasta, Chile, S. A.
Walker, G. E., N. Metropolitan Elec. Pr. Supply Co., Willesden, N. W., 10, London, Eng.
Total 10

STUDENTS ENROLLED JUNE 27, 1923

17248 Kurtz, William E., Stevens Inst. of Tech.
17249 Cooper, Wilfrid B., Stevens Inst. of Tech.
17250 Smith, Everett F., Univ. of Illinois
17251 Anderson, William R., Oregon Institute of Technology
17252 Berger, Clarence E., Oregon Agri. Coll.
17253 Carpenter, Dale, Ohio Northern Univ.
17254 Woods, Stephen R., Univ. of Tennessee
17255 Walton, Ivan R., University of Utah
17256 Hausman, Sidney, Stevens Inst. of Tech.
17257 Burchett, Albert C., Jr., Univ. of Tenn.
17258 Beardsley, Frank D., Stanford University
17259 Covey, Frederick A., Stanford University
17260 Redeker, Ivan M., Stanford University
17261 Snow, William B., Stanford University
17262 Spaulding, Harold S., Stanford University
17263 Waterman, Edward C., Stanford Univ.
17264 Wright, Robert F., Stanford University
17265 Zelhart, George E., Stanford University
17266 Coyle, Daniel K., Stanford University
17267 Cooper, Lloyd E., Stanford University
17268 Crawford, Casper G., Stanford University
17269 Koch, George O., Stanford University
17270 Vinsonhaler, George R., Stanford Univ.
17271 Wright, Andrew C., Stanford University
17272 Weaver, Irvin J., Ohio Northern Univ.
17273 Havens, Donald C., Stevens Inst. of Tech.
17274 Marshall, Roland B., Purdue University
17275 Morrill, Wayne J., Purdue University
17276 Asmussen, Carl T., Purdue University
17277 Bridge, L. R., Purdue University
17278 Rogers, Thomas J., Syracuse University
17279 Barnes, Jean C., Ohio Northern University
17280 Ingram, William H., Jr., A. & M. College of Texas
17281 Schmitt, Paul M., Worcester Poly. Inst.
17282 Perry, Homer I., Worcester Polytechnic
17283 Fort, Tomlinson, Jr., New Mexico College of A. & M. Arts
17284 Kositzky, James C., Univ. of Nebraska
17285 Otto, Ralph D. M., University of Utah
17286 Hendrix, Louis A., New Mexico College of A. & M. Arts
17287 Kepp, Karl, University of Washington
17288 Van Wyk, Hessel, University of Utah
17289 Ohlson, Otto O., State Coll. of Washington
17290 Huggler, Luther R., Penn. State College
17291 Cole, Irving V., Stevens Inst. of Tech.
17292 Adams, Lyndon O., University of Illinois
17293 Sellers, John F., Purdue University
17294 Bauman, Chester E., Purdue University
17295 Lyon, Hamann, University of Michigan
17296 Kelly, Harold V., Univ. of Michigan
17297 Kruszka, Joseph F., Univ. of Michigan
17298 Leet, Cecil, University of Michigan
17299 Bouillon, Lincoln, University of Penn.
17300 Hawke, Le Roy F., Univ. of Delaware
17301 Healy, E. Kennedy, Univ. of Nebraska
17302 Palomeque, Alonso E., Cornell Univ.
17303 Mapes, Charles M., Mass. Inst. of Tech.
17304 Sawyer, Paul U., Univ. of Arizona
17305 Osborn, Roy P., Univ. of Arizona
17306 Gilman, George W., Mass. Inst. of Tech.
17307 Murphy, Thomas B., Jr., Pennsylvania State College
17308 Morrell, Stanley A., Northeastern Univ.
17309 Prout, George R., Mass. Inst. of Tech.
17310 Fassitt, Andrew J., Northeastern Univ.
17311 Chen, C. Henry, Univ. of Michigan
17312 Brown, William A., University of Michigan
17313 Wolfert, Edward R., Univ. of Michigan
17314 Hall, Cecil G., Univ. of Michigan
17315 Booker, Jack W., Univ. of Arkansas
17316 Bauman, Harold A., Columbia Univ.
17317 Price, J. Pressly, Stanford University
17318 Pearce, George C., Stanford University
17319 Harcourt, Irl R., Stanford University
17320 Kahn, Frank, University of Pennsylvania
17321 Wottrich, Herbert, Stevens Inst. of Tech.
17322 Bridges, William D., Oregon Agri. Coll.
17323 Birkmeyer, Paul J., Ohio State Univ.
17324 McElwee, Robert McC., Ohio State Univ.
17325 Meissner, Charles R., Univ. of Penn.
17326 Vance, Paul A., University of Illinois
17327 Livadary, John P., Mass. Inst. of Tech.
17328 Stark, J. Howard, University of Illinois
17329 Ambrose, W. B., University of Texas
17330 Flook, Walter D., Montana State College
17331 Morrow, William D., A. & M. Coll. of Tex.
17332 Buerk, Frederick C., Univ. of Wisconsin
17333 Eachimoree, Herbert M., Univ. of Denver
17334 Cole, Mortimer, Stevens Inst. of Tech.
17335 Baldwin, Morris J., Univ. of Maryland
17336 McKinnon, Hugh D., Mass. Inst. of Tech.
17337 Over, Harold A., University of Illinois
17338 Gage, Frank D., Mass. Inst. of Tech.
17339 Nelson, Eiven E., Oregon Agri. College
17340 Dakin, Hursey A., Oregon Agri. College
17341 Krishna, Rama, Lewis Institute
Total 94

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H. P. Gibbs, Tata Sons, Ltd., Navsari Building, Fort Bombay, India.
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Lawrence Birks, Public Works Department, Wellington, New Zealand.
W. Elsdon-Dew, P. O. Box 4563, Johannesburg, Transvaal, Africa.

A. I. E. E. COMMITTEES

(A list of the personnel of Institute committees may be found in the June issue of the JOURNAL.)

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MEETINGS AND PAPERS, E. E. F. Creighton
PUBLICATION, Donald McNicol
COORDINATION OF INSTITUTE ACTIVITIES, W. I. Slichter
BOARD OF EXAMINERS, H. H. Norris
SECTIONS, A. W. Berresford
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INDUSTRIAL AND DOMESTIC POWER, H. D. James
INSTRUMENTS AND MEASUREMENT, G. A. Sawin
IRON AND STEEL INDUSTRY, E. S. Jefferies
LIGHTING AND ILLUMINATION, G. H. Stickney
MARINE, G. A. Pierce, Jr.
MINES, Graham Bright
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PROTECTIVE DEVICES, H. R. Woodrow
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TRANSMISSION AND DISTRIBUTION, Edward B. Meyer

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(The Institute is represented on the following bodies; the names of the representatives may be found in the June issue of the JOURNAL.

COUNCIL OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
AMERICAN BUREAU OF WELDING
AMERICAN COMMITTEE ON ELECTROLYSIS
AMERICAN ENGINEERING COUNCIL OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES
AMERICAN ENGINEERING STANDARDS COMMITTEE
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U. S. NATIONAL COMMITTEE OF THE INTERNATIONAL ILLUMINATION COMMISSION
U. S. NATIONAL COMMITTEE OF THE INTERNATIONAL ELECTROTECHNICAL COMMISSION
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A. I. E. E. SECTIONS AND BRANCHES

A list of the 46 Sections and 70 Branches of A. I. E. E., with the names of their officers, may be found in the June issue of the JOURNAL.

DIGEST OF CURRENT INDUSTRIAL NEWS

NEW CATALOGUES AND OTHER PUBLICATIONS

Panelboards.—Bulletin 29, 12 pp. Describes Type "P" Standardized Panel Boards manufactured by the Frank Adam Electric Company, St. Louis, Mo.

Signal Line Wire.—Bulletin, 4 pp., contains technical data and table on copper clad signal line wire manufactured by the Copper Clad Steel Company, Rankin, Penn.

Watthour Meters.—Bulletin 61, 20 pp. An instruction book covering Sangamo Type H single and polyphase watthour meters. Sangamo Electric Company, Springfield, Ill.

Theater Lighting.—Bulletin 28, 36 pp. "The Control of Lighting in Theaters." Describes in detail the Major System manufactured by the Frank Adam Electric Company, St. Louis.

Precision Balancing Machine.—Bulletin, 4 pp. Describes a new precision balancing machine for accurately measuring and locating unbalance in rotative parts. Gisholt Machine Company, Madison, Wis.

Electric Furnace.—Bulletin 3, 12 pp., describing the new Ajax-Northrup 35-kv-a. converter and the various standard high-frequency furnaces which may be operated from it. Ajax Electrothermic Corporation, Trenton, N. J.

Solderless Connectors.—New price sheets covering all types and sizes of Dossert connectors are ready for distribution. The sheets are Electrical Supply Jobbers Association standard size. Dossert & Company, 242 West 41st St., New York.

Transmission Line Accessories.—Bulletin 1-A, 4 pp., describes high-tension splicing sleeves for transmission line, ground wire and telephone conductors, and twisting tools for seamless copper splicing sleeves. The High Tension Company, 120 Broadway, New York.

Control Relays.—Bulletin 47672, 8 pp. Describes control relays to be interposed between circuit breaker solenoid and control switches and used for the remote control of circuit breakers when it is undesirable to have the control current pass through the control switch. General Electric Company, Schenectady, N. Y.

Lightmeter.—Booklet, 12 pp., shows the details of construction of the new "Holophane Lightmeter" and gives instructions in its use. Should be of particular interest to electrical engineers of central stations and municipal engineers. The Holophane Glass Company, Inc., 342 Madison Ave., New York.

Lighting Data.—Bulletin LD 106A, "Illumination and Production;" Bulletin LD 145, 24 pp., "Lighting of Theaters and Auditoriums;" Bulletin LD 146, 28 pp., "Stage Lighting;" Bulletin LD 118A, 32 pp., "The Incandescent Lamp—Its History." Each bulletin contains a bibliography on the subject covered. Edison Lamp Works of General Electric Company, Harrison, N. J.

Amperehour Meter.—Bulletin 62, 24 pp., describing the locomotive type amperehour meter manufactured by the Sangamo Electric Company, Springfield, Ill. The meter automatically gives the true indication of the state of charge or discharge of a storage battery at all times, and in addition, automatically terminates the charge at the proper time. This meter has been especially designed to meet the severe requirements in mine locomotive, electric and industrial truck service.

Illumination.—Booklet, 38 pp. "Holophane Datalog"—Commercial Edition. Devoted to illuminating engineering data and includes utilization coefficients for all types of Holophane luminaires and reflectors worked out for various size rooms with various wall and ceiling reflection factors. Describes types used for window, school, office, factory and yard lighting, and reflectors for special uses. Typical photometric distribution curves are shown for each reflector type. The Holophane Glass Company, Inc., 342 Madison Ave., New York.

The Westinghouse Electrical Supply Catalog for 1923-24 is now being distributed. In all, 1300 pages are devoted to descriptive matter, technical data, dimension drawings, specifications and prices. The material includes all new apparatus developed in the last two years. The catalog is indexed according to subjects and to sections. In addition, a new feature—a classified index—has been added to the introductory section. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Penn.

NOTES OF THE INDUSTRY

The Foxboro Company, Inc., Foxboro, Mass.—Recording and Indicating Instruments. C. H. Roessner has been appointed District Sales Manager at Chicago. He will have his central offices at 1510 Monadnock Building.

A. F. Mundy, formerly of the Chicago office, will represent the company in southern California, with offices in the Pacific Finance Building, Los Angeles.

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Penn., recently acquired the plant of the Savage Arms Corporation at Sharon, Pa., which is now being remodeled and equipped for the manufacture of transformers. It is expected that the plant will begin operation next fall. The transformer division of the East Pittsburgh Works of the Westinghouse Company will be transferred to Sharon, and 3000 persons, including a large number of girls and women, will be employed in the new Westinghouse plant when it begins operation. C. H. Champlain, formerly assistant works manager at East Pittsburgh, has been appointed works manager of the Sharon plant.

Edwin L. Wiegand Company, Pittsburgh, Penn.—The United States District Court of the Northern District of Ohio, recently rendered a decision in the patent controversy between Edwin L. Wiegand of Pittsburgh and the Dover Manufacturing Company of Dover, Ohio. The court upheld thirteen out of the fourteen claims of the Wiegand Patent No. 1,133,347, a basic patent covering equipment used in the manufacture of embedded heating elements. The court also refused to hold invalid the Wiegand article and process patents No. 1,154,953 and No. 1,136,076 respectively. It was decreed that the Dover Company has a limited shop right to manufacture and sell electric sad irons containing certain of Wiegand's inventions made during his employment by them from 1911 to 1914. This, however, does not permit the Dover Manufacturing Company to use the Wiegand patents on the improved processes and equipment subsequently developed and used by Edwin L. Wiegand Company in the manufacture of their line of Chromolox Heating Units of which they are the only authorized source. Also, the customers and licensees of Edwin L. Wiegand Company are safe from any claim by the Dover Manufacturing Company which is decided to have no patent rights outside of this limited shop right.

OBITUARY

Chauncey C. Baldwin, for more than twenty years connected with the Standard Underground Cable Company at Perth Amboy, N. J., died at his residence there June 7, 1923, aged 57, after a brief illness. He had been one of the outstanding figures in the copper rolling and wire drawing industry for many years, starting first with Wallace & Sons as superintendent, later building and operating the Waclark plant at Bayonne, N. J., and afterwards the rod and wire mills of the National Conduit and Cable Company at Yonkers. His connection with the Standard Underground Cable Company dated from 1902 as superintendent and manager of its Metal Departments at Perth Amboy, including its copper melting furnaces and equipment for the production of copper and brass rods and wire, tubes, weatherproof and magnet wire products. In 1916 he was elected a vice-president of the company, which position he held at the time of his death.